



Defense Health Board

Sustainment and Advancement of Amputee Care

April 8, 2015

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DEFENSE
HEALTH
BOARD

**OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
HEALTH AFFAIRS**

7700 ARLINGTON BOULEVARD, SUITE 5101
FALLS CHURCH, VA 22042-5101

April 8, 2015

**MEMORANDUM FOR ACTING UNDER SECRETARY OF DEFENSE (PERSONNEL AND
READINESS)**

SUBJECT: Sustainment and Advancement of Amputee Care

The Defense Health Board (DHB) is pleased to submit its report on the Sustainment and Advancement of Amputee Care (attached). On June 20, 2013, the Acting Under Secretary of Defense for Personnel and Readiness requested that the DHB develop recommendations for the sustainment of the remarkable advancements made in amputee care during the conflicts in Iraq and Afghanistan and recommend strategies for continuing to advance the field to maintain readiness for future conflicts. The DHB tasked its Health Care Delivery Subcommittee with conducting a review of the full spectrum of amputee care and developing a strategy for the sustainment and advancement of amputee care skills and technology for the Board's consideration.

The Subcommittee reviewed the state of amputee care in the Military Health System (MHS), received briefings from experts, and visited the Advanced Rehabilitation Centers, where state-of-the-art amputee care is delivered. The Subcommittee also reviewed relevant peer-reviewed literature and conducted panel discussions with leaders in the field of amputee care.

On behalf of the DHB, I appreciate the opportunity to provide the Department with this independent review of the spectrum of amputee care in the MHS and recommendations to sustain and advance the field.

A handwritten signature in black ink, reading "Nancy W. Dickey MD".

Nancy W. Dickey, M.D.
President, Defense Health Board

Attachment:
As stated

cc:
ASD(HA)

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"With 25 years of experience on which to build, it's become apparent that amputations, burns, and brain injuries are not necessarily career ending, especially with the evolution of new technologies that enable service members to function at a much higher level than in the past."

"We intend to keep faith with our military family by focusing on the abilities of our veterans, not on their disabilities. We intend to continue to lead advancements in treating traumatic injury, specialty training and education, and sustainment programs."

"The health and well-being of our military family is essential to our national security and the future of the force."

"Military service is about belonging, about meaning, and about a variety of experiences. We must continue to inspire those who are serving now and those who will volunteer to serve in the future."

General Martin E. Dempsey
Chairman of the Joint Chiefs of Staff¹



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EXECUTIVE SUMMARY

“Let me tell you about the care I received at Walter Reed. It was second to none. The staff was professional, supportive and encouraging. These high-tech arms and legs are my livelihood. I placed complete trust in the medical staff and because of the team, I can live a successful and happy life today. Because of these state-of-the art legs I can now drive my daughter to pre-school, take my wife to the movies and live a functional, normal life in society. That would not have happened without the great care I received at Walter Reed. Everyone from the medics, to the surgeons, to the occupational and physical therapists, to the prosthetist and all the support staff in between contributed as a team to my recovery. I am forever grateful.”

United States Army Staff Sergeant Travis Mills,
Quadruple amputee and motivational speaker²

“It’s almost impossible to believe how far we have all come together. I attribute the success of this amazing young couple[,Jay Raffetto, Marine and triple combat amputee, and wife Emily,] to all of the incredible medical support up front, the love and support of so many friends and relatives, the Marines, their good jobs, and most importantly their love of each other and their unwavering positive attitude and very hard work.”

John Raffetto, about his son³

Operation ENDURING FREEDOM (OEF), Operation IRAQI FREEDOM (OIF), and Operation NEW DAWN (OND) brought new injuries and new challenges as Service members sustained significant traumatic injuries during their combat deployments, including loss of limb function. As a result, the Department of Defense (DoD) established three Advanced Rehabilitation Centers (ARCs), in which amputees receive state-of-the-art, integrated care and access to the latest technology in prosthetics and assistive devices, becoming the world leader in amputee care. While DoD currently provides excellent amputee care, the Department was not prepared to care for the many Service members who experienced amputations at the start of the Iraq and Afghanistan conflicts, as much of the amputee care skills and knowledge gained from previous conflicts were lost because of a shifting of priorities during the interwar years. To sustain this level of competency and to maintain readiness in the event of future conflicts, it is critical that the advancements made in amputee care during OEF/OIF/OND not be lost. Indeed, DoD should strive to expand on its current capabilities to ensure that the current cohort of amputees continue to receive high-quality care and that a state of readiness for amputee care is maintained into the future.

On June 20, 2013, the Under Secretary of Defense for Personnel and Readiness (USD(P&R)) requested the Defense Health Board (DHB) review the full spectrum of amputee care, and define a strategy for preserving and continuing these advancements, identifying the best possible care for DoD’s beneficiaries. In response to this request, the DHB assigned its Health Care Delivery Subcommittee to research current literature, receive briefings from, and consult with components of DoD. Additionally, the Health Care Delivery Subcommittee gathered information from Service recruiting commands and recognized experts in the field of amputee care and research.



The resulting examination focuses on: 1) the current landscape of DoD's amputee research and care; 2) DoD's approach to and system for amputee care; 3) care of the amputee; and 4) data, surveillance, and research translation.

Findings and Recommendations

The extraordinary character and will of the amputees and their families are indispensable components of the achievement of unprecedented positive outcomes. The motivation, determination, *esprit de corps*,^a perseverance, and attitude of the amputees, along with the unflagging support of their families, has shaped and revitalized the paradigm of care.

Overarching Finding 1: The extraordinary character, fierce resiliency, and never-quit attitude of combat wounded amputees, along with the sacrifice and selflessness of family members and combined with expert total care has led to extraordinary results, enabling amputees to return to active duty, even combat, and a high quality of life.

Recommendation 1: DoD must never forget the primary importance of the individual combat casualty, family members, and the care team.

In the OEF/OIF/OND conflicts, DoD developed groundbreaking technologies to meet the needs of its unique patient population and its distinctive combat injuries. At the start of the conflict, military medicine was not prepared to provide high-quality care to the large number of traumatic amputees. However, amputee care capabilities have since advanced dramatically, substantially improving the quality of care and life for amputees and expanding the horizons of the military medical community.

Finding 2: Although DoD is providing excellent amputee care, failure to sustain and advance medical readiness in peacetime has limited DoD's capability to deliver high-quality traumatic amputee care in the past and may threaten that capability in the future.

Recommendation 2: DoD must ensure sustainment of the highest quality delivery of health care and health research in spite of post-conflict resource limitations. Core competencies in optimal amputee care must be defined, periodically updated, tracked, and regularly reported to the leadership of the Military Health System (MHS).

Current Landscape of DoD Amputee Care

It is important that future DoD amputee care provide for lifelong care and support for the current cohort of traumatic amputees and anticipate the needs of future cohorts of Service members who may sustain amputation(s) as a result of traumatic limb injuries. Because of advances in medical care, young, otherwise healthy combat amputees may now live long, active, and productive lives. Based on the unique nature of their injuries, DoD recognizes that these patients will require lifelong care; however, a gap remains in understanding the full range of long-term health needs of this amputee population.

^a*Esprit de corps*: The common spirit existing in the members of a group and inspiring enthusiasm, devotion, and strong regard for the honor of the group.⁴



Finding 3: The long-term health, health care needs, health care utilization, and health outcomes of DoD amputees from OEF/OIF/OND present knowledge gaps that require investigation.

Recommendation 3.1: DoD should maintain a centralized registry of amputees to gain an understanding of the health, health care needs, and health care utilization of this population.

Recommendation 3.2: DoD should conduct retrospective and prospective cohort studies of current military amputees to advance the ability to enhance outcomes. The Extremity Trauma and Amputation Center of Excellence may be well suited to conduct these studies.

Recommendation 3.3: DoD should continue to prioritize research and drive improvements across the spectrum of disciplines that affect the care and quality of life for amputees, their caregivers, and support systems.

DoD has developed three state-of-the-art amputee care facilities, the Military Advanced Treatment Center, the Center for the Intrepid, and the Comprehensive Complex Casualty Care Center, to treat the combat amputees of the OEF/OIF/OND conflicts. These Amputee Care Centers (ARCs) provide state-of-the-art care to DoD beneficiaries, as well as civilians and international amputees. Their unique interdisciplinary team approach to providing care has resulted in unprecedented innovation and advancement in amputee care and technology.

Finding 4: Establishment of the ARCs has created a multidisciplinary system of care that is holistic and patient- and family-centered. This has resulted in unprecedented opportunities to attain higher levels of functioning for the amputee.

Recommendation 4: DoD must ensure that adequate resources are provided in order to maintain the current model of multidisciplinary, holistic, and patient- and family-centered care.

The amputee care model developed by DoD in recent conflicts is dependent on integration of amputees, their families, and their caregivers with a variety of community, academic, and government organizations. This integrated rehabilitation approach enhances the quality of care for amputees by providing peer and community support in addition to innovative treatment options brought about by scientific and medical partnerships. Strengthening existing and developing new supporting relationships with the civilian and military communities and the Department of Veterans Affairs (VA) can provide continuity of care and ongoing reintegration support.

Finding 5: Over the course of the current conflicts, DoD has created a new paradigm featuring the interprofessional team approach to amputee care that shifts the focus to ability rather than to disability. This approach improves the quality of life for those who have experienced amputations and sustains progress in the field of amputee care, supporting improved DoD operational readiness.



Recommendation 5.1: DoD must provide the resources and facilitate the partnerships needed to enhance supportive rehabilitation opportunities for amputees that focus on their abilities and allow them to return to active duty when capable.

Recommendation 5.2: DoD should prioritize efforts for reintegration of amputees into their communities and daily living.

The remarkable advancements in amputee care are the outcome of multiple collaborations among DoD, the VA, academia, industry, and civilian partners. Each element of this dynamic network of collaborations will continue to be critical in sustaining the current level of care and advancing the science and technology needed to provide state-of-the-art care for amputees in the future. Therefore, it will be important to protect and continue to foster this network moving forward, strengthening existing partnerships, and broadening the scope and variety of collaborations.

Finding 6: Collaborations with institutions, practitioners, and researchers across a variety of disciplines and organizations are critical to DoD's sustainment and advancement in the field of amputee care.

Recommendation 6: DoD should implement formal funding mechanisms and relationships that institutionalize collaboration between DoD and a broad reach of academic medical centers, health care systems, engineering schools, and other institutions important to advancing amputee care.

The DoD ARCs are world leaders in amputee care. If DoD's mission allows, the unparalleled care that the ARCs provide could be made available more broadly to traumatic amputees across the United States and potentially around the globe. Providing care for foreign nationals at the ARCs may provide DoD practitioners access to the patient load necessary to sustain their skills and expertise.

Finding 7: DoD has established national and international partnerships that have the potential both to benefit amputee care in the military and civilian communities and to ensure ongoing access to amputees to maintain critical military readiness and amputee care skills.

Recommendation 7.1: DoD should continue, sustain, and grow amputee care partnerships on both the national and international levels.

Recommendation 7.2: DoD should establish a national and international telehealth center of excellence capability that promotes consultative partnerships and access to excellent care for amputee patients.

Recommendation 7.3: DoD should maximize the provision of care for civilian traumatic extremity injury and amputation patients and explore the feasibility of, where appropriate, providing care to international amputee patients in the ARCs to bolster case flow.



DoD Approach to and System of Care

To accelerate the rate at which innovations in amputee care and technology are incorporated into every day care, DoD has embedded researchers within the clinical ARC settings. Within the ARCs, patients and clinicians work directly with researchers to push the limits of technology, driving the field forward. Because of this unique care setting, the ARCs have become the place

to which others in the field of amputee care turn when seeking best practices and state-of-the-art science. Although this close partnership among patients, researchers, and health care professionals has produced promising results, it has not always been formally structured. A formalized process and system for collaboration may provide the infrastructure to support ongoing innovation and allow for the collection of data to determine the success of new treatments.

Finding 8: The ARCs have demonstrated synergy between clinical care and research that provides for the rapid translation of new research advances into amputee care. However, the approach would be better sustained if it were deliberate, documented, and coordinated.

Recommendation 8: DoD should systematize the methodology and codify the current synergy between clinical care and research through targeted funding and strategic use of personnel, particularly with respect to the rapid translation of research into practice. Based on its charter, the Extremity Trauma and Amputation Center for Excellence is well situated to do this within MHS, VA, and civilian practice.

DoD often collaborates with the VA and civilian institutions to conduct or participate in training and education. Training and continuing education opportunities vary in response to provider needs as well as technology capabilities, taking the form of webcasts; intensive classes, conferences and symposia; fellowships; and even telecommunications-supported grand rounds across multiple locations.⁵ The ARCs participate in training and education for amputee care; however, formalized graduate education relationships between the ARCs and educational institutions and health systems do not exist. As such, valuable training and collaborative opportunities may be overlooked and amputee care may not be effectively incorporated into health care professional skill development and training.

Finding 9: The Subcommittee found that while the ARCs do interface with medical entities and medical training programs, they do not provide residencies, fellowships, or other postgraduate programs.

Recommendation 9: DoD should collaborate with educational institutions and accredited programs to provide graduate and postgraduate training experiences in ARC settings in order to build and maintain provider expertise and ensure health professionals are up to date on the most recent advancements in amputee care.

The Subcommittee found it difficult to identify standardized metrics and obtain complete data regarding the operating costs of the ARCs. Challenges associated with medical coding, in addition to the unique and varied structures of the ARCs, make it difficult to accurately quantify the costs of patient care in the ARCs.



Finding 10: It is currently impossible to comprehensively determine the cost of DoD’s amputee care programs. One cannot determine value without accurate data on cost. Although limited data related to the cost of amputee care exist, these data are not collected systematically or organized for easy access and analysis.

Recommendation 10: DoD should refine its data management systems and processes to allow comprehensive and comparative analyses of the total cost of amputee care.

Expert opinion makes clear that the ARCs require a minimum caseload to sustain the skills of the amputee care team and ensure that amputee care providers maintain proficiency in amputee care. This threat to maintaining clinical competency in the ARCs may be ameliorated through the use of simulations, and the effects of the decreased patient load may be mitigated through national and international amputee care partnerships. However, neither of these initiatives, alone or in combination, appear likely to be sufficient to sustain all three ARCs during peacetime.

Finding 11: A critical mass of clinicians, technical specialists, and new trauma patients are needed to sustain amputee care skills. Expert opinion has universally concluded that DoD does not have adequate patient load during peacetime to sustain the clinical competency of its amputee care team.

Recommendation 11: DoD should build and strengthen national and international partnerships that allow for U.S. civilian or international amputees to receive care services in the ARCs, increasing the caseload of new traumatic amputees.

Finding 12: There has been a significant decrease in the number of new traumatic amputees requiring care and available resources to sustain the care capability. To maintain the provider competencies and system capabilities in the interwar years, adequate caseload is necessary.

Recommendation 12: DoD should seek every conceivable opportunity by looking both within current models and outside existing ones to build the caseload necessary to sustain and advance state-of-the-art total amputee care, clinical competency, and expertise. If DoD exhausts every effort to build a caseload sufficient to sustain these current centers, then, and only then, should consideration be given to consolidation into a single center of excellence in order to sustain medical readiness in this critical component of casualty care.

Care of the Amputee

DoD is committed to the lifelong well-being of its Service members. Preventive medicine is critical in this regard, as studies have demonstrated that the long-term effects of living with an amputation lead to negative health outcomes that are significantly more serious than those of non-amputees.⁶ Creation and maintenance of long-term amputee patient registries that track health outcomes through amputees’ lifetimes would allow providers and researchers to better predict chronic disease risks for this unique population. It is important to address primary health concerns early to prevent, minimize, and slow the development of associated secondary and tertiary health concerns later in life.



Finding 13: The ARCs lack robust clinical and research programs designed to enhance the long-term health of the amputee population, reduce the risk of premature mortality, and manage comorbidities associated with amputations.

Recommendation 13: The ARCs should develop, pilot, and evaluate prevention and wellness programs to better manage comorbidities and reduce the risk of long-term chronic disease for amputees.

The main goal of amputee care is to return the individual to independence and productive functioning in daily life. In the recent OEF/OIF/OND conflicts, more amputees are returning to duty because of the remarkable advancements made in amputee care. To meet the needs of this extraordinary patient population, DoD has redefined amputee care and rehabilitation, enabling wounded Service members to attain levels of functioning previously thought impossible, and in many cases returning them to active duty.

Finding 14: DoD has established a process and infrastructure specifically aimed at supporting amputees to return to active duty, which is vital to DoD's future operational readiness in addition to improving the quality of life for those who have sustained traumatic limb injuries.

Recommendation 14: DoD should continue to advance the progress that allows amputees to return to active duty.

Data, Surveillance and Research Translation

The congressionally mandated VA Extremity Trauma and Amputation Center of Excellence (EACE) was established to develop and implement a comprehensive strategy for the mitigation, treatment, and rehabilitation of amputees and to conduct research on amputee and extremity injury care.⁷ To facilitate this research, EACE established the EACE Registry (EACE-R), which tracks civilian and military, conflict-related and non-conflict amputees, limb-salvage patients, and those who receive the Intrepid Dynamic Exoskeletal Orthosis™ (IDEO™) brace. The EACE-R has the potential to aid EACE in fulfilling its congressional mission. However, while progress has been made, the EACE-R still requires extensive development and resources to achieve these goals.

Finding 15: The EACE is not accomplishing the full mandate of its congressional charter as included in the National Defense Authorization Act (NDAA) of 2009.

Recommendation 15.1: The VA Under Secretary for Health and DoD Under Secretary for Personnel and Readiness should conduct an in-depth assessment of the organization and funding of EACE with the intent of optimizing performance.

Recommendation 15.2: Based on the Board's review, San Antonio would be the optimal geographic location for an enhanced EACE. The combined resources of the San Antonio Military Medical Center, the Center for the Intrepid, the Institute for Surgical Research, the Audie L. Murphy Medical Center, the VA affiliate University of Texas



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Medical School, and the University of Texas San Antonio offer an impressively rich setting for this center of excellence.

The rapid translation and application of research and technology into care has been central to rapid advances in amputee care during the recent conflicts. This has been most notable in the areas of prosthetics and orthotics, limb salvage, transplants, and regenerative medicine. Embedded researchers and prosthetists at the ARCs, in addition to close collaboration between patients and their health care providers, have allowed for rapid innovation and application of new technologies to improve the state of amputee care. This rapid research cycle, developed in response to the recent conflicts, has yielded a new paradigm for the delivery of state-of-the-art care.

Finding 16: The research and care processes, rapid prototyping, and applied research that have been achieved in recent years were lacking at the beginning of the conflicts. However, the close proximity of research and clinical personnel has led to breakthroughs in research, general medical care, and prosthetic care.

Recommendation 16: DoD should maintain and disseminate lessons learned from tactical combat casualty care and the rapid cycle research in amputee care, including the colocation of research and clinical care to ensure the effective and timely application of innovations in the delivery of care and to optimize resources.

Conclusions

DoD now provides excellent care for Service members who experience amputation as a result of their service. This new level of care was achieved through a strong network of collaborations, as well as a unique paradigm of care that focused on an interdisciplinary care team and the colocation of researchers and prosthetists in the clinical setting. This paradigm results in rapid advancements in technology and care and must not be lost during times of peace as has been the case historically. To sustain and advance the current state of amputee care in the future, DoD must continue to provide resources that support partnerships with academic, health care, and civilian organizations; ensure sufficient training and education opportunities for health care professionals; engage in research on the long-term needs of amputees to inform preventive health care programs; and maintain the rapid research and implementation of new technologies in the clinical setting. Above all, DoD must continue to prioritize the health of its Service members, providing amputee care that is dynamic, multi-faceted, and lifelong.

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1. BACKGROUND AND INTRODUCTION

“The veterans who have left their limbs on the battlefield have done so in the service of all of us. The resilience and spirit of these men and women serve as an inspiration to us all.”

Hon. Michael J Kussman, Brigadier General, U.S. Army (Retired)
Undersecretary of Health, Veterans Health Administration,
U.S. Department of Veterans Affairs⁸

Many men and women serving with the United States military during Operation ENDURING FREEDOM (OEF), Operation IRAQI FREEDOM (OIF), and Operation NEW DAWN (OND) have sustained traumatic injuries during their service. A significant number have incurred amputations and loss of function to their extremities.^{9,10} Although improvements in protective gear and body armor and advancements in military medicine, particularly in acute in-field care, have significantly improved survival from traumatic injury, loss of extremities continues.^{11,12} Thus, a growing number of young, high-performing Service members now are living with amputated limbs,^{11,13} resulting in a unique amputee population with specific needs and long-term treatment challenges.

Technological and clinical advances achieved in response to the needs of this distinctive cohort of amputees have transformed the clinical practice and the philosophy of military amputee care and rehabilitation. Moreover, the extraordinary character of these Wounded Warriors and their families has been integral to this transformation. It is critical to the Department of Defense’s (DoD’s) mission that these advancements not be lost but rather sustained and expanded in the event of future conflicts.

Overarching Finding 1: The extraordinary character, fierce resiliency, and never-quit attitude of combat wounded amputees, along with the sacrifice and selflessness of family members and combined with expert total care has led to extraordinary results, enabling amputees to return to active duty, even combat, and a high quality of life.

Recommendation 1: DoD must never forget the primary importance of the individual combat casualty, family members, and the care team.

Injuries resulting in death, even as recently as 10 years ago, have dramatically decreased, and hundreds of Wounded Warriors and amputees return to active duty, including combat deployments, or active civilian life. As DoD relies on an all-volunteer force, recruits are more likely to volunteer their service to the Nation when assured of a system dedicated to providing excellent care in the event they are injured. Historically, DoD has been a leader in the field of amputee care. Its cadre of experienced practitioners and development of best practices contribute significantly to the management of civilian mass casualty situations in the United States and improved care of those experiencing amputations. Thus, military expertise in amputee care enhances not only the health and readiness of the U.S. Armed Forces, but also the health and well-being of civilians injured both in the United States and around the world.



In the interwar periods throughout U.S. military history, there have been observed declines in medical readiness, including amputee care capabilities, in spite of the military's intent to maintain full medical readiness. Previously, best practices and lessons learned in amputee care were not systemically preserved or formally disseminated to improve military medicine in future conflicts or to facilitate knowledge translation to the broader civilian medical community. The Subcommittee deliberated at length about the entire issue of medical readiness, of which amputee care is one element, in order to find ways to help DoD think through these challenging times. In the recent conflicts in Iraq and Afghanistan, advances in medical and surgical infrastructure have produced new levels of excellence across the continuum of amputee care. These achievements provide DoD with an opportunity to formally document, validate, and disseminate new knowledge, and to properly specify the infrastructure and approach needed to sustain and continuously advance the Department's amputee care now and into the future.

1.1 HISTORY AND EVOLUTION OF U.S. MILITARY AMPUTEE CARE

Traumatic amputation is an age-old consequence of combat. Individuals have sustained major limb amputations since the earliest recorded wars in U.S. military history.¹³ Amputation related to traumatic injury has been a significant health consequence of OEF/OIF/OND, consistent with health outcomes of other major conflicts in U.S. military history.^{14,15} From a historical perspective, it is notable that the numbers of Service members undergoing amputation as a result of past conflicts (detailed in Table 1) have often far exceeded those of the current conflicts.¹⁴⁻¹⁶

Table 1. U.S. Military Amputee Numbers by Conflict

Conflict	Civil War	World War I	World War II	Korean War	Vietnam War	Persian Gulf War	OEF/OIF
Amputee Numbers	>21,000 (Union)	4,000	15,000	1,000	6,000	15	1,626 (9/1/2013) ¹⁶

From Scoville, 2013;¹⁶ Pasquina, 2009.¹⁵

Owing to significant numbers of amputee patients and the high level of morbidity and mortality (historically, one in three) associated with amputations proximal to the wrist or ankle,¹⁷ care for the amputee must be paramount. Because data collection has varied from conflict to conflict, it is not possible to draw direct comparisons of specific amputee survival rates across time and conflicts. However, it is clear that amputee survival rates, including survival of multiple extremity amputees, have increased, particularly during the recent conflicts in Iraq and Afghanistan.^{14,18} Many factors have affected the decline in case fatality rates,^b including “lessened battlefield lethality, better personal protective equipment, improved battlefield first-aid training, far-forward placement of surgical teams, more sophisticated surgical care, and markedly decreased medical evacuation times.”¹⁴

^b Case fatality rate is defined as “the fraction of an exposed group – all those wounded in action including all those who die (at any level), expressed as a percent.”¹⁹



During the Civil War, about 75 percent of surgical operations performed were amputations, with more than 21,000 Union soldiers being survivors of those amputations.^{20(p21)} Amputations were associated with high death rates because of the poor conditions in the field hospitals. Physicians did not have sterile operating theaters and the surgical technology was quite basic. Walt Whitman described the reality of those amputations after visiting a Civil War hospital: “a heap of amputated feet, legs, arms, hands, and...human fragments, cut, bloody black and blue, swelling and sickening.”^{21(p6)} Postsurgical infections were rampant as antiseptics and disinfectants were not yet widely utilized.²¹ Although Civil War amputees were provided prostheses, amputations left many of the residual limbs with “ragged tissue and protruding bones, or bones left close to the surface of the skin, [which] caused immense pain and frustration for amputees who tried to use prostheses.”^{20(p23)} Even after surviving an amputation, limited ability to execute daily living activities consequent to ill-fitting and primitive prostheses often led to poor quality of life for the amputee.

World War I (WWI) brought a renewed focus on advancing amputee care along with the establishment of rehabilitation programs for amputees modeled after those in Great Britain. However, the end of the war was associated with a dramatic diminution of resources for military amputee care, and amputees faced increased challenges that neither military nor civilian agencies were equipped to address, including the needed ongoing care and reintegration support.²⁰

WWII served as a catalyst to reinvigorate DoD efforts to improve amputee care and by the end of the War movements to advance research and care for traumatic amputees were well established. Informed by the experience of WWI, the U.S. Army launched programs specializing in amputee rehabilitation issues that concentrated resources and various health care providers involved in amputee care and rehabilitation.^{14,15,20} During that time, military policy on amputee care also evolved. At the beginning of WWII, DoD policy directed that wound stabilization and provision of temporary limbs to combat amputees be followed by rapid transition to the Department of Veterans Affairs (VA) where amputees were to be provided with more advanced prosthetics and ongoing care. By the end of WWII, DoD had launched a prosthetics research program and policy directed the provision of the highest quality prosthetics available.^{14,15} The Department engaged with and encouraged action from Congress, which passed the first prosthetics research bill in 1943. This was followed by a 1945 National Academy of Sciences conference on improvements in the performance of artificial limbs. In 1947, the amputee rehabilitation research program was transitioned from DoD to the VA and affiliated amputee research centers were established at New York University, Northwestern University, and the University of California at Los Angeles.^{14,15}

The Korean and Vietnam Wars brought the introduction and widespread adoption of the use of helicopters for rapid transportation of Wounded Warriors from the battlefield to more fully equipped medical teams and facilities for complex casualty care. Transport time shrank to 1 to 2 hours during the Vietnam War from 12 to 15 hours during WWII, improving combat casualty survival, including that of traumatic amputees.¹⁴

Many of the lessons learned and improvements in care adopted from the Vietnam War were documented by Brown in 1994,²² which informed future care and advances that are still reflected in current best practices. These included establishing specialized treatment centers;



incorporating rehabilitation principles early in the care process; limiting convalescent leave; introducing recreational and motivational activities; better defining the VA's role in amputee care; and providing holistic and team care.¹⁵ The Vietnam War era also introduced an important shift away from loss- or problem-focused treatment toward motivational and therapeutic treatment,²⁰ which has continued to evolve into the present-day rehabilitation philosophy. The corresponding shift in the VA amputee system of care is best embodied by the Veterans' Health Care Eligibility Reform Act of 1996, which required the VA to maintain its capacity to provide specialized care for patients with amputations and other disabilities.²³ The Federal Advisory Committee on Prosthetics and Special Disability Programs was established with express intent to advise the VA on provision of state-of-the-art specialized care and rehabilitation services for veterans with disabilities.²⁴ This committee is still active today.

Attention and resources dedicated to the care of traumatic amputees tend to wax and wane coincidental with U.S. military war activity. Significant technological, scientific and health systems breakthroughs in amputee care have coincided with each conflict, but lulls in advancement between conflicts have been detrimental to military readiness, the military medical mission, and the well-being of Service members who have endured sacrifices in service to the Nation. During times of peace, there is a tendency to turn the focus away from advancement in combat medicine, and military health care priorities drift towards peacetime health care and maintenance. Medical technical skills and core competencies often are lost because of the significant decrease in traumatic amputee patient load or different patient needs related to non-traumatic amputations. This drop in patient load leads to sparse practice opportunities for practitioners, reduced research efforts, and diminished activity in the field overall. Thus, amputee-related professional exchanges, relationship building, communications, and systems and process utilization are curtailed.

To the extent that systems and processes have been documented and preserved, progress in amputee care and lessons learned from each conflict have informed future care and fostered continued improvements. However, too often, standard documentation and formal transmission of lessons, advances, and capabilities in amputee care have not been sustained for future application. This lack of information transfer has repeatedly resulted, as with OEF/OIF/OND, in a new steep learning curve, expensive and time-consuming re-establishment of infrastructure and capabilities, and redundant "discoveries" with each new conflict.¹⁶ The poor retention and application of knowledge and practices developed during previous conflicts has likely contributed to unnecessary loss of life and limb. It must be noted that since the Subcommittee began to meet, there have been developments in the global arena, with U.S. ground, sea, and air deployments in combination with other coalition forces into the Iraq and Syria combat theaters. Since U.S. Military deployments continue, care should be taken to ensure that the loss of knowledge and readiness seen in the past does not occur.

RECENT DEVELOPMENTS

In planning for OEF/OIF amputee care, the U.S. Army designated Walter Reed Army Medical Center (WRAMC), now Walter Reed National Military Medical Center (WRNMMC), as its primary location to provide amputee care.¹⁵ As in previous conflicts,²⁵ DoD in 2007 responded to the unique needs of its growing cohort of combat amputees by formally establishing three Advanced Rehabilitation Centers (ARCs): the Military Advanced Training Center (MATC), the



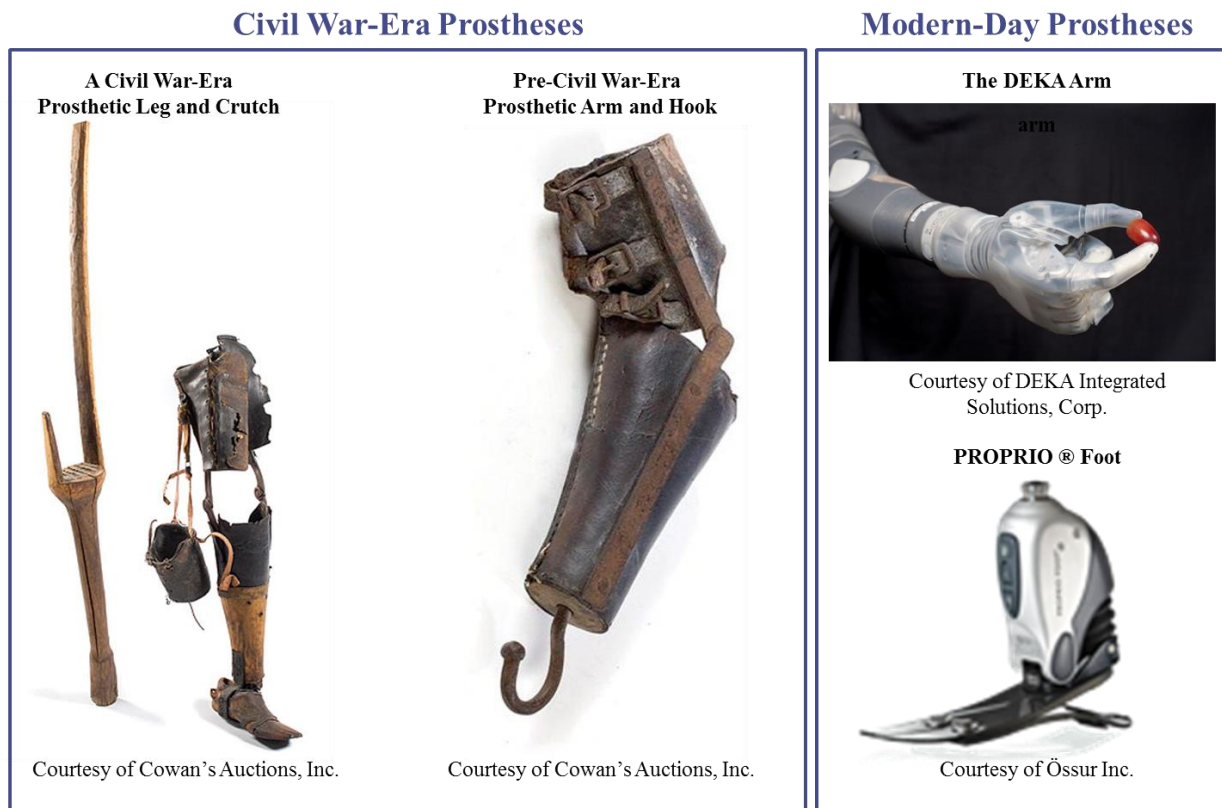
Center for the Intrepid (CFI), and the Comprehensive Combat and Complex Casualty Care (C5) Program. All three ARCs were established through congressional mandate. CFI was built with philanthropic assistance from two civilians, Arnold and Ken Fisher, who funded its construction.²⁰ The ARCs concentrate the Department's amputee care resources and providers in three locations to provide holistic patient care and management through an integrated, interdisciplinary team approach using innovative technologies in a sports medicine paradigm.²⁶ The ARCs are described in further detail in Section 2.

With significant resources and attention now focused on three comprehensive amputee care centers, development of interagency partnerships, extraordinary scientific and technological advances, and a unique and highly motivated patient population, DoD has dramatically transformed amputee care and assistive technology. Modern advances have created a stark contrast between the outcomes, quality of life, and overall image of past amputees versus those of present day amputees. The Civil War amputee received a stump leg and wooden crutches or a wooden peg and metal hook in place of a hand to maneuver tasks of daily living as best he could.²⁷ With today's new era of care, individuals who have sustained major limb amputation(s) may return to high-functioning activities, such as re-deployment on active duty, running, surfing, fishing, rock climbing, and living in homes without special accommodations. This evolution of amputee care and prostheses is indebted to centuries of conflict that repeatedly focused military medicine on improving the care of the amputee.

Progress in the art and science of care for amputees has been paralleled by progress in prosthetic development. The contrast between Civil War era and modern day prosthetic limbs is portrayed in Figure 1. Made of wood and steel, Civil War prosthetic limbs were largely uncomfortable and inefficient, and most veterans of the time preferred crutches over the prosthetics available.²⁷ Today's prostheses, exemplified in Figure 1 by the DEKA Arm and PROPRIO[®] foot, utilize a variety of materials to provide maximum efficiency and comfort, with many options allowing selection for fit to task and terrain. Experts in the field suggest that in the near future amputees will shop online for prosthetic attachments much as people shop online for shoes.



Figure 1. Civil War-Era and Modern-Day Prosthetic Limbs²⁸⁻³¹



Images adapted from DEKA Research and Development Corporation. The DEKA arm. 2014. Össur Americas. 2014. Cowan's Auctions, Inc. 2014.

Advances in technology and materials science have not only increased comfort and efficiency, but also have helped reduce stigma and change the image of amputation and prostheses.³² The use of prosthetics in body art (see Figure 2) and recent debate concerning whether the J-shaped prosthetic leg provides an unfair advantage in professional running, including at the Olympic level, are further examples of the evolution of prosthetics and orthotics.³³



Figure 2. Prosthetic Body Art³²



Courtesy of Sophie de Oliveira Barata, Alternative Limb Project, 2014.

In order to meet the needs of its unique patient population with distinctive combat injuries, military medicine once again has moved the field dramatically forward, rapidly influencing the quality of care and life in the broader medical community and general population as well as the military community.

Finding 2: Although DoD is providing excellent amputee care, failure to sustain and advance medical readiness in peacetime has limited DoD's capability to deliver high-quality traumatic amputee care in the past and may threaten that capability in the future.

Recommendation 2: DoD must ensure sustainment of the highest quality delivery of health care and health research in spite of post-conflict resource limitations. Core competencies in optimal amputee care must be defined, periodically updated, tracked, and regularly reported to the leadership of the Military Health System.

1.2 A UNIQUE PATIENT POPULATION

Although there are more amputees across the Nation³⁴⁻³⁶ and around the world,^{37,38} DoD's traumatic amputee population is unique in cause, character, and need. The majority of amputations sustained by civilians and veterans in the United States are non-traumatic and largely related to diabetes, peripheral vascular disease, or other chronic medical conditions.³⁹ Even the infrequent amputations that occur as a result of traumatic injury in civilian settings often include different types of trauma than those experienced by active duty Service members.¹² The vast majority of DoD's amputees have experienced traumatic injuries and resulting amputation of a limb from a combat-related blast. As of June 1, 2014, 1,648 U.S. Service members had sustained such traumatic injuries in the recent conflicts in Iraq and Afghanistan,⁴⁰



and as of 2011, more than 20 percent of DoD's traumatic amputees have sustained multiple amputations.²⁶

Furthermore, DoD's traumatic amputees are significantly younger and healthier than civilian and veteran amputees at the time of their amputations, with more than 85 percent of Service members being under the age of 35, and more than 81 percent of civilians and veteran amputees being more than 44 years old.¹² As active duty Service members prior to their traumatic injuries, these young combat amputees were healthy, extremely fit, and high performing, often at the level of Olympic athletes,¹² while civilian and veteran amputees, whose amputations generally result from chronic health conditions,³⁹ were comparatively less healthy and less fit prior to their amputation(s).

An additional distinction consistently noted by amputee care providers is the extremely high intrinsic motivation and extraordinary character of the combat amputee.¹⁴ This motivation is often expressed by Wounded Warriors as the desire to return to active duty, return to the unit, and return to full functionality with the same vigor as before, or compete in Paralympic sports.³³ Wounded Warriors also enjoy remarkable family support and an *esprit de corps* that provides additional motivation and psychosocial reinforcement from which amputees outside of the Armed Forces do not benefit.

As a result of the combat amputee population's unique injuries, character, and context, its care and rehabilitation needs also are distinctive. For example, because of patients' high level of intrinsic motivation, care providers usually do not have to provide inspiration to push the amputee toward recovery as in traditional approaches to rehabilitation. Rather, providers are pushed to identify more rigorous and innovative approaches to meet the demands of the amputee. Through this patient-provider interplay, outcomes are achieved that were never thought possible. Service members with double amputations walk on prosthetic limbs, and hundreds of amputees have returned to active duty, with more than 50 redeploying.^{40,41} Although not yet demonstrated through data collection and research, it may be that DoD's population of young amputees is at higher risk of developing comorbidities earlier in life than non-amputees or other amputee populations who sustain amputations later in life. Therefore, it is important that a deeper understanding of this population's lifelong needs be achieved, and that tailored fitness programs and other clinical preventive services are provided for this cohort of Wounded Warriors.

1.3 FUTURE NEEDS AND CHALLENGES

It is equally important that future DoD amputee care include both lifelong care for the current cohort of traumatic amputees as productive and active members of society, as well as future cohorts of Service members who may sustain amputation(s) as a result of traumatic limb injuries. Strategies for sustaining and continuously improving the Department's amputee care will need to address both populations. Thanks to advances in protective gear and medical care, young, otherwise healthy combat amputees are now looking forward to decades of active and productive life. DoD recognizes amputee care as lifelong care; however, a gap remains in understanding the long-term consequences and sequelae among this amputee population. Gaining understanding of the lifelong needs of this population can only be accomplished through observing and studying their experiences over the course their lifetimes. This knowledge will help develop and define lifelong support and care for this cohort and future cohorts of this unmatched population of



traumatic and combat amputees. In addition, it is critical to sustain and continue to advance the skills and knowledge of practitioners in the specialized fields that play significant roles in amputee care, such as medicine, technology, and social and material sciences. This need is especially critical as the acute patient load dwindles during interwar years.

Finding 3: The long-term health, health care needs, health care utilization, and health outcomes of DoD amputees from OEF/OIF/OND present knowledge gaps that require investigation.

Recommendation 3.1: DoD should maintain a centralized registry of amputees to gain an understanding of the health, health care needs, and health care utilization of this population.

Recommendation 3.2: DoD should conduct retrospective and prospective cohort studies of current military amputees to advance the ability to enhance outcomes. The Extremity Trauma and Amputation Center of Excellence may be well suited to conduct these studies.

Recommendation 3.3: DoD should continue to prioritize research and drive improvements across the spectrum of disciplines that affect the care and quality of life for amputees, their caregivers, and support systems.

1.4 REQUEST TO THE DEFENSE HEALTH BOARD

The Defense Health Board (DHB) has maintained long-standing interest in the area of amputee care throughout the recent conflicts, and has addressed it previously through the Panel for the Care of Individuals with Amputations and Functional Limb Loss (herein referred to as “the Panel”). The Panel, Chaired by GEN (Retired) Frederick Franks, was initially established in 2002 as a Board of Directors at Walter Reed Army Medical Center, and first met in 2003.⁴² Under the DHB, the Panel transitioned to a Subcommittee during 2006 and 2007. This was followed by an April 11, 2008 request from the Deputy Assistant Secretary of Defense for Force Health Protection and Readiness that the DHB create a Task Force. It was specifically requested that the Task Force “review and provide recommendations to address how the DoD should maintain clinical competency within amputee care centers in a post-conflict setting, as well as to determine the post-conflict amputee care infrastructure and how should it be financially maintained.”^{43(p1)}

Key issues identified by the Task Force as being essential included: the need to centralize amputee care in a few core treatment facilities; establishment of an executive agency that would have control over all three centers;^{42,44} support of ongoing research funding and sustainment of clinical competency; ensuring that amputee care delivery specifically addresses the mental health needs of these patients; inclusion of family and peer support in care;^{45,46} and the need to clarify Continuation on Active Duty/Continuation on Active Reserve versus Fit for Duty findings and their effects on the Wounded Warrior^{46,47} The group also suggested that the U.S. Army Institute for Surgical Research Burn Center be considered as a potential model for the sustainment of care and expertise.⁴⁷ Additionally, the Task Force highlighted the need to improve patient transitions from DoD to the VA, and noted the importance of highlighting good news stories of amputee



experiences.⁴⁸ Upon receiving briefings from the Task Force, DHB discussed the sustainability of amputee care after drawdown and whether all three centers would then be needed.⁴⁸ DHB provided an update to the Assistant Secretary of Defense for Health Affairs on June 16, 2008, suggesting forward movement and next steps; however, it did not submit formal recommendations to the Department. As the result of a Secretary of Defense efficiency initiative, the group was consolidated into the DHB Health Care Delivery Subcommittee.⁴⁹

In anticipation of the needs and challenges of providing amputee care following OEF/OIF, the Acting Under Secretary of Defense for Personnel and Readiness (USD(P&R)) on June 20, 2013 endorsed (Appendix A) a request from the Chairman of the Joint Chiefs of Staff for DHB (or the Board) to review the spectrum of amputee care and to recommend a strategy for preserving and continuing advances in care, identifying the best possible care to DoD beneficiaries (see Appendix B). The Chairman's request followed discussions between the Chairman and DHB member GEN (Retired) Frederick Franks, a retired four star and a combat amputee. On behalf of the Board, GEN (Retired) Franks expressed the urgency the Board felt with regard to this issue.

In response to USD(P&R)'s request, the Board assigned the Health Care Delivery Subcommittee (hereafter referred to as "the Subcommittee") to review the issue. The Subcommittee developed Terms of Reference (see Appendix C) to define the scope of the investigation, to include:

1. Review the full spectrum of amputee care;
2. Identify and list sources of best practices at the levels of field trauma care, initial surgery, reconstructive procedure, and rehabilitation;
3. Determine how to maintain continued advancements as the drawdown of the Force takes place;
4. Identify areas of clinical and technologic research for DoD to support; and,
5. Determine strategies to ensure that the military sustains the existing level of excellence.

1.5 GUIDING PRINCIPLES

The Subcommittee felt that it was especially important at the outset of the review to establish Guiding Principles (See Figure 3) to lay the foundation for and underpin its review. The principles reflect the Subcommittee's core beliefs regarding the role of DoD in developing strategies in response to the Board's recommendations.



Figure 3: Guiding Principles

Overarching Principle: It is the duty of DoD to provide state-of-the-art, world-class care to those Service members who experience amputation as a result of their service. Furthermore, DoD must take significant steps to ensure the preservation and enhancement of the level of excellence in care over time.

Guiding Principles: These principles require that the changes recommended by the Subcommittee, when taken as a whole, must:

1. Result in continued advancements in the efficiency and quality of amputee care by, among other approaches, reflecting best practices in the government, private sector, and internationally;
2. Take into consideration current DoD initiatives, undertakings, and future plans;
3. Identify gaps in clinical and technologic research, and offer solutions that will provide for the best available, state-of-the-art care to return each amputee to his/her maximum performance capability;
4. Develop a clear, actionable strategy, including specific and feasible actions, for sustaining and continuing advances in amputee care;
5. With due consideration of cost implications and existing constraints, maintain amputee-related health care benefits to the fullest extent possible; and
6. Promote the development of metrics that provide a basis for enhancing accountability and improving cost-effectiveness in current amputee care while providing objective evidence for continuous improvement in care for future generations of amputees.

In sum, what is needed is a focus on preserving the best aspects of current amputee care, while sustaining and advancing the delivery of accessible, high-quality care over the long term in order to return amputees to their maximum performance capabilities.

1.6 METHODS

In addressing USD(P&R)'s request, the Subcommittee reviewed the spectrum of amputee care and strategies to maintain and advance the current level of excellence. The Subcommittee met in person and by telephone to receive briefings from subject matter experts, DoD personnel involved in amputee care efforts, and amputees themselves. In coordination with the DoD-VA Extremity Trauma and Amputation Center of Excellence (EACE), members also conducted site visits of the three DoD ARCs: MATC at Walter Reed National Military Medical Center; CFI at San Antonio Military Medical Center; and C5 at the Naval Medical Center San Diego, as well as the Army Institute for Surgical Research Burn Center. Appendix D contains a complete list of briefings received and care facilities toured during each meeting.

In addition, members reviewed supporting documentation provided by the DoD amputee care centers, as well as literature concerning amputee care-related issues (such as research, patient loads, provider competencies, and prosthetic advancements) and best practices for addressing them. The Subcommittee then presented its preliminary findings and positions to the DHB for



consideration and deliberation. The members used quantitative data when available, and qualitative measures where data did not exist.

1.7 ORGANIZATION OF THE REPORT

This report addresses the five sets of issues posed in the Terms of Reference and fully responds to USD(P&R)'s request. Section 2 provides an analysis of the current landscape of DoD amputee care. Section 3 assesses DoD's approach to and system of amputee patient care. Section 4 provides an overview of the unique care needs of the traumatic amputee, highlighting long-term health concerns and technological advances. It also discusses the impact of the return of traumatic amputees to active duty on operational readiness. Section 5 focuses on data collection, surveillance, and research translation to ensure that amputee care continues to advance, even in interwar years.

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2. CURRENT LANDSCAPE OF DEPARTMENT OF DEFENSE AMPUTEE RESEARCH AND CARE

“Our country’s Warriors – Soldiers, Sailors, Airmen, and Marines – who are wounded or injured as a consequence of their service deserve the highest quality care available.”

Lieutenant General Eric B. Schoomaker, Surgeon General and
Commanding General, U.S. Army Medical Command⁵⁰

Over the past 15 years, the Department of Defense (DoD) has developed a robust infrastructure, integrated system and approach, and dynamic ecosystem of collaborations to meet the unique needs of, and provide the best care in the world for its growing and unparalleled cohort of traumatic amputees.

2.1 OVERVIEW OF THE INJURIES LEADING TO AMPUTATION

Most amputations among active duty Service members are traumatic amputations, the vast majority of which are related to injuries sustained in combat. While many digital amputations occur, the care and needs of major limb amputees is significantly different from those of digital amputees. As such, the Department’s amputee care system (and this report) focuses on traumatic injuries that lead to major extremity amputation. A major extremity amputation is commonly defined as any amputation of a limb that is “at or proximal to the carpal or tarsal joints,”^{51(p2)} which excludes finger(s), thumb(s), and toe(s).⁵²

DEPARTMENT OF DEFENSE AMPUTATION TRENDS

For an understanding of the most common types of amputations sustained by this population, Krueger and colleagues provided a thorough analysis of amputation trends from the beginning of Operation ENDURING FREEDOM (OEF), Operation IRAQI FREEDOM (OIF), and Operation NEW DAWN (OND) in 2001 through July 2011.¹¹ The analysis identified 1,221 amputees who had sustained a total of 1,631 amputations as of that time. Krueger et al reported just less than 4 amputations for every 100 trauma admissions, and just more than 5 for every 100,000 deployed Service members. As depicted in Figure 4, the most common types of amputation were transtibial at 40 percent and transfemoral at 35 percent. Fourteen percent of amputations were of the upper extremity and 30 percent of amputees had multiple amputations, most of which were bilateral lower extremity amputations. This marks a significantly higher multiple amputee rate than the 2- to 20-percent rate reported in previous wars.^{11,18}

A review of amputations sustained by Service members by military occupational specialty (MOS) between October 1, 2001 and July 30, 2011 by Belisle and colleagues characterized amputation patterns, subsequent disability, and ability to return to duty.⁴¹ The study found that the majority of DoD’s amputations take place among U.S. Army and U.S. Marine Corps Infantry and combat engineers.⁴¹ The overall pattern of amputations and the severity of injuries sustained by amputees as measured by Injury Severity Scores (ISS) are similar across MOSs.⁴¹ Additionally, “combined disability ratings” and “disability code representation” were

comparable among MOS.⁴¹ These findings indicate that while some MOSs are at higher risk for amputation, those who sustain amputation(s) average the same level of injury and outcomes.

Traumatic injuries have occurred more frequently (60 to 70 percent of the time) in an extremity than in the head and torso during OEF/OIF/OND^{12,53}, as the use of improved personal protective equipment on the head and torso has provided protection for those areas but leaves the limbs exposed and vulnerable. Traumatic amputations characteristic of the current conflicts are most often caused by high-energy improvised explosive devices (IEDs) resulting in severely mangled extremities and highly complex wounds, including catastrophic bone and soft-tissue damage with heavy debris contamination.^{12,14}

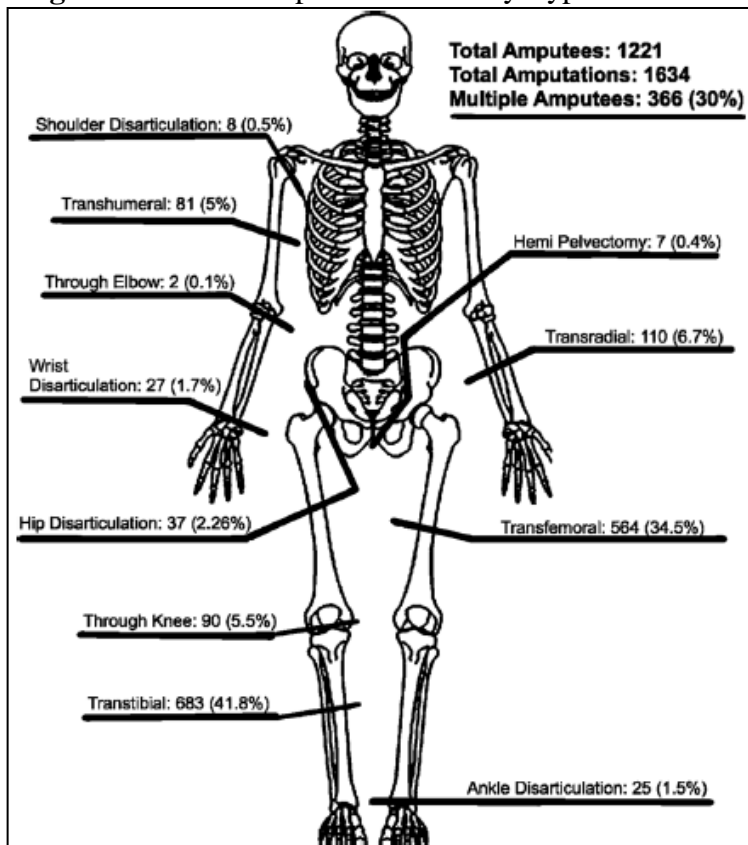
ASSOCIATED INJURIES AND COMORBIDITIES

In addition to the highly complex injuries that require amputation(s), military traumatic amputees almost always sustain multiple associated traumatic injuries and live with numerous comorbidities, complicating both acute and long-term care. By their nature, IED blast injuries resulting in extremity amputation nearly always cause combined penetrating, blunt, and burn injuries as well as extensive perineal and genitourinary injuries.¹⁸ Spine fractures have been documented at 13 percent among lower extremity traumatic amputees.⁵⁴ The traumatic amputee often sustains soft tissue wounds in other areas in addition to the amputation, and remaining limbs often sustain fractures, nerve injuries, and infections.^{11,12,18,25}

After amputation, heterotopic ossification, defined as the abnormal formation of bone growth within the soft tissue of a residual limb, occurs in as much as 64 percent of combat amputations.²⁶ Heterotopic ossification can impair joint range of motion, make prosthetic fitting difficult, and cause residual limb pain as well as frequent skin breakdown.²⁶

The psychological health effects, injuries, and comorbidities associated with traumatic amputations also are significant. Traumatic brain injury (TBI) affects one third of DoD's traumatic amputees, and posttraumatic stress disorder (PTSD) affects one fourth, in addition to a high incidence of anxiety, depression, and an array of psychosocial stressors.¹² It is also important to note that mental health issues are consistently underreported,^{55,56} suggesting that

Figure 4. DoD Amputation Rates by Type¹¹



From Krueger, et al, 2012, pS440.



actual rates of TBI, PTSD, and other mental health diagnoses are likely to be higher than those recorded and reported here.

As an associated traumatic injury, TBI has received particular attention in traumatic amputee care. TBI may significantly impede amputee rehabilitation efforts, as it can interfere with the patient's abilities to understand, follow commands, and adhere to tasks, all of which are necessary for successful rehabilitation. A study by Harvey and colleagues stated, "it is best for patients with TBI that significantly interferes with their rehabilitation requirements to be transferred to a facility for specialized TBI care and later return to an amputee care facility as necessary, after sufficient recovery from the TBI has been attained."^{26(p51)}

The myriad associated injuries and comorbidities contribute to the complexity of the infrastructure, resources, science, skill, and approach to care needed to provide for the Department's traumatic amputees. This complexity has caused DoD to implement a focused approach that specifically targets this patient population within DoD's broader medical mission. Appendix E provides a timeline of key milestones in DoD amputee care history between 2001 and 2011.

2.2 DEPARTMENT OF DEFENSE AMPUTEE CARE

DoD's health care system, the Military Health System (MHS), provides care for active and retired Service members and their families and has among its areas of focus the mission to provide combat casualty care. As such, DoD amputee care is delivered within the context of the MHS. DoD has established a complex system of levels of care described in Figure 5.

These levels of care are unique and differ from the American College of Surgeons' levels of trauma care centers. The levels of care, previously referred to as "echelons," denote differences in medical capability, not quality of care.⁶² Joint Staff doctrine delineates four levels of care,⁵⁷ and literature published by the provider and research communities widely acknowledge a fifth level of care within the continental United States (CONUS).^{58,59,61,63} Acute trauma care begins at the point of injury, often far forward in the area of combat, and progresses through increasingly sophisticated levels of care as the Wounded Warrior is transferred out of the combat zone and back to CONUS. For those with

Figure 5. The Levels of Military Medical Care

- I:** Immediate first aid and lifesaving measures at the front line, which can include the use of the tourniquet provided to each Service member as well as evacuation to nearest aid station or platoon for initial resuscitation and initiation of advanced trauma life support;⁵⁷
- II:** Surgical resuscitation provided by highly mobile forward surgical teams that directly support combatant units in the field;⁵⁷
- III:** Combat support hospitals, which are large facilities that take time to become fully operational but offer much more advanced medical, surgical, and trauma care, similar to a civilian trauma center;⁵⁷
- IV:** Definitive surgical management provided outside the combat zone; and⁵⁷
- V:** Care provided at one of the major military treatment facilities (MTFs) within the United States, where definitive stabilization, reconstruction, or amputation of the injured is performed.⁵⁸⁻⁶¹



traumatic extremity injuries, definitive fracture stabilization, wound closure, and the decision regarding whether or not to amputate an injured limb are generally delayed until the patient reaches a Level V care facility within CONUS.^{15,58} A sixth level of care that includes the implementation of long-term rehabilitation and support for traumatic amputees is discussed in the existing amputee care literature, but it is not part of current military doctrine. This sixth level of care has historically been primarily provided by the VA, but DoD's Advanced Rehabilitation Centers (ARCs) also provide state-of-the-art treatment in these areas.¹⁵

ADVANCED REHABILITATION CENTERS

Military Advanced Training Center

The Military Advanced Training Center (MATC) at Walter Reed National Military Medical Center (WRNMMC) is located in Bethesda, Maryland, in relatively close proximity to an aeromedical staging facility at Andrews Air Force Base. The amputee care center at Walter Reed Army Medical Center (WRAMC) was conceptualized in 2004 and built in 2007. As a result of the 2005 Base Realignment and Closure (BRAC), the facility at WRAMC transitioned to WRNMMC in 2011 and opened as the MATC.⁶⁴ MATC utilized lessons learned and increased understanding of the provision of optimal amputee care during the early years of the conflict to improve design of its new facility to meet the unique care needs of traumatic amputees.¹⁶ MATC was the first of the ARCs to be formally established. Even prior to WRNMMC and MATC's establishment, their predecessors, WRAMC and its amputee care program, had already been providing care to traumatic amputees as the U.S. Army's designated amputee care center since the beginning of the conflicts in Iraq and Afghanistan. MATC not only provides well-seasoned practitioners, many of whom have led the advancement of amputee care since the early years of the current conflicts, but it also is the only ARC on the East Coast, and, being in the National Capital Region, boasts singular entree into partnerships and collaborations with neighboring national organizations such as the National Institutes of Health, the Institute of Medicine, and the headquarters of the VA, as well as other leading academic and scientific institutions.

MATC is well known for its clinical care and research in the field of amputee care. WRNMMC has its own Institutional Review Board and has established a separate review board in the Orthopaedics Department to oversee clinical investigations involving amputee patients.¹⁶ MATC has also begun to include civilian amputees in its research, and has also participated in many preclinical trials for new devices before they reach the market. Finally, MATC stands out as providing care to the largest patient population of any of the three ARCs, nearly double that of Center for the Intrepid (CFI), which has the second largest patient load.

Center for the Intrepid

In 2007, CFI was established in San Antonio, Texas, at the San Antonio Military Medical Center (SAMMC). Distinguishing features of CFI are rooted in its location at SAMMC, and the associated military medical infrastructure, which makes it the only ARC to be co-located with an American College of Surgeons-designated Level I Trauma Center. It is also co-located with the Extremity Trauma and Amputation Center of Excellence (EACE), the congressionally-designated DoD-VA center of excellence for amputee care, as well as the U.S. Army Institute of Surgical Research (USAISR), thus placing it at the hub of DoD trauma care and research. The



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USAISR Burn Center is also located at SAMMC. Colocation of this ARC and the USAISR Burn Center offers enhanced care opportunities for those Service members who have sustained severe burn wounds in addition to traumatic injuries that resulted in amputation or limb salvage efforts. The nearby Contingency Aeromedical Staging Facility (CASF), which opened at Wilford Hall Medical Center in 2011, serves as an additional asset to CFI, providing care support for those patients being transported through the aeromedical evacuation system. Additionally, the San Antonio, Texas area, in contrast to the other ARCs, offers a significantly lower cost of living and therefore cost to DoD to support amputees and their families while receiving care. The area also provides more opportunity for temporary housing at affordable rates than the geographic areas surrounding MATC and the Comprehensive Combat and Complex Casualty Care (C5).

CFI's facilities stand out among the ARCs. The center has benefited from the generosity of the Fischer family's gift that funded the construction of modern, state-of-the-art facilities that include an indoor FlowRider wave pool that supports both recreation and rehabilitation activities. While all three ARCs utilize common equipment, CFI's facilities and equipment often surpass typical rehabilitation technology. For example, while all three ARCs use Computer Assisted Rehabilitation Environment (CAREN) systems, CFI has the first of only two dome-style CAREN systems in the world. Additionally, while the on-site prosthetics laboratory is a hallmark of each ARC, CFI's prosthetics laboratory embodies patient participation and peer support in its construction and set up, as the fitting and walking practice area is in the prosthetics waiting area for amputees.

In addition, CFI exemplifies the most robust execution of the integrated multidisciplinary team among the three ARCs and has dramatically influenced the scope of amputee care with the invention (by a former CFI scientist) and first implementation of the Intrepid Dynamic Exoskeletal Orthosis (IDEO)TM. CFI subsequently trained and supported the other two ARCs in deploying the IDEOTM for their patients. CFI has also formalized some aspects of collaboration with the VA through a resource-sharing agreement, placing seven full-time VA employees within CFI to support its operations. In exchange, CFI provides care for VA amputees at no charge to the VA until the cumulative cost of care provided to VA amputees exceeds the cost of the VA staff.⁶⁵ This agreement naturally enhances DoD-VA coordination and aids in patient transitioning from DoD to VA care.⁶⁶ The center has also begun to pursue enhanced collaboration with the VA through local academic partners.

Comprehensive Combat and Complex Casualty Care Program

When established as an ARC, C5 built on its extensive physical medicine and occupational therapy program and integrated multidisciplinary care approach and added comprehensive rehabilitative care for amputees.⁶⁷ The center is now distinguished among the ARCs by several unique clinical components and provides services to combat injured beyond amputees.⁶⁸ It includes a Comprehensive Aesthetic Restorative Effort program (Project CARE), which proactively includes aesthetics as part of a patient's comprehensive care, treating scarring, traumatic tattooing, and other injuries to restore function and/or improve appearance.⁶⁸ In addition, a traumatic brain injury (TBI) program is embedded within C5, and the center is collaborating with a pain research group, since TBI is a common comorbid injury and pain is difficult to manage among those who sustain traumatic amputations.^{67,68} Although the C5



Program has had the smallest patient population of the three ARCs through the current conflicts, it boasts the best climate and geographical setting of all three ARCs, fostering a high quality of life with year-round access to various outdoor rehabilitative and recreational activities for amputees.

Proximity to the Naval Health Research Center (NHRC) has led to research collaborations between the two organizations including longitudinal studies of individuals who sustain severe musculoskeletal injuries.⁶⁷ Similarly, being closely situated to the VA health care center in San Diego has facilitated collaboration with the VA^c in addition to educational agreements with multiple universities to train Doctorate of Physical Therapy and Occupational Therapy students.⁶⁷ C5 has also collaborated with the Johns Hopkins Applied Physics Laboratory to analyze C5 workload and processes to maximize amputee care throughput and services and develop significant electronic management tools. The tools have enhanced patient tracking, rehabilitation timeline management, and data reporting, and also support the ability to model future capacity determinations.⁶⁸ Finally, C5 staff indicated to the Subcommittee that discussion is under way for a potential future collaboration to establish what would be a privately funded DoD/VA/civilian-collaborative “one-stop-shop” amputee care center.⁶⁹

Early during the conflicts in Iraq and Afghanistan, before the three ARCs had been established, it became clear that the facilities and approach to care available at that time were not adequately suited to the rehabilitation of the new and unique amputee population.⁶⁴ Now, with model facilities, a standardized approach to care reflecting lessons learned, and continuously advancing clinical care and research, the three ARCs are “recognized as the best in the world”^{64(p4-1)} at providing traumatic amputation and limb salvage care. The ARCs have served as the model for the establishment of several rehabilitation facilities around the world.⁶⁴

Finding 4: Establishment of the ARCs has created a multidisciplinary system of care that is holistic and patient- and family-centered. This has resulted in unprecedented opportunities to attain higher levels of functioning for the amputee.

Recommendation 4: DoD must ensure that adequate resources are provided in order to maintain the current model of multidisciplinary, holistic, and patient- and family-centered care.

The ARCs also actively collaborate with EACE, and the Uniformed Services University of the Health Sciences to provide multidisciplinary and specialty training and educational opportunities for practitioners across the continuum of amputee care.^{5,64} As illustrated by the ARCs, DoD has increasingly partnered with the VA to provide long-term rehabilitation and care to traumatic amputees during the recent conflicts in Iraq and Afghanistan to meet the needs of the young and unique OEF/OIF amputee population.^{15,5858}

^c C5’s collaborations with the VA include plans for integrating more care (short- and long-term) under the medical services umbrella agreement, support for VA transition services, a VA/DoD (NMCSO) Joint Incentive Fund for satellite amputee clinic establishment, and another for cross credentialing of providers to and from VA and NMCSO.⁶⁸



The amputee care model developed by DoD in recent conflicts is dependent on integration of amputees, their families, and their caregivers with a variety of community, academic, and governmental organizations. These relationships enhance the quality of care for amputees by providing peer and community support, in addition to innovative treatment options brought about by scientific and medical collaborations. These options can include counseling, employment and education opportunities, peer support for rehabilitation, prosthetic advancements, athletic programs, and competitions, such as warrior games. Continuing to prioritize effective communication and strong support by the Services will foster meaningful and active amputee and family member engagement throughout the care and rehabilitation process. This can be accomplished by strengthening existing and developing new supporting relationships with community and local organizations. This could also be supported by strengthened collaboration between DoD and the VA, which can provide continuity of care and ongoing reintegration support.

Finding 5: Over the course of the current conflicts, DoD has created a new paradigm featuring the interprofessional team approach to amputee care that shifts the focus to ability rather than to disability. This approach improves the quality of life for those who have experienced amputations and sustains progress in the field of amputee care, supporting improved DoD operational readiness.

Recommendation 5.1: DoD must provide the resources and facilitate the partnerships needed to enhance supportive rehabilitation opportunities for amputees that focus on their abilities and allow them to return to active duty when capable.

Recommendation 5.2: DoD should prioritize efforts for reintegration of amputees into their communities and daily living.

Because of the lull in the need for amputee care after the Vietnam War, DoD lost many of its operational capabilities to provide the full spectrum of traumatic amputee care. Consequently, it took years to rebuild and enhance the knowledge, skills, professional exchange, relationships, communications, and systems and process utilization that make the state-of-the-art system of amputee care what it is today.⁷⁰ Now, it is apparent that DoD is leading the Nation and the world in extremity trauma and amputee science and care through its infrastructure, systems, and approach.⁷⁰

DoD-VA EXTREMITY TRAUMA AND AMPUTATION CENTER OF EXCELLENCE

In 2009, Congress mandated the establishment of DoD-VA centers of excellence (CoEs) through Public Law 110-417 in the National Defense Authorization Act of 2009, section 723. These CoEs focused on specific identified health-related needs of those wounded in active duty during OEF/OIF/OND. Among others, the mandate included a CoE for amputee care. EACE was established in response to that mandate, and is required:

1. To implement a comprehensive plan and strategy for the Department of Defense and the Department of Veterans Affairs for the mitigation, treatment, and rehabilitation of traumatic extremity injuries and amputations.



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2. To conduct research to develop scientific information aimed at saving injured extremities, avoiding amputations, and preserving and restoring the function of injured extremities. Such research shall address military medical needs and include the full range of scientific inquiry encompassing basic, translational, and clinical research.
3. To carry out such other activities to improve and enhance the efforts of the Department of Defense and the Department of Veterans Affairs for the mitigation, treatment, and rehabilitation of traumatic extremity injuries and amputations.⁷

As such, the congressional intent is for EACE to serve as the principal integrator among the three ARCs and facilitate a unified DoD-VA strategy for amputee care. Hallmarks of DoD amputee care, standardized and institutionalized by the ARCs and EACE and facilitated by the infrastructure and systems in place, include an interdisciplinary and sports medicine approach to care, an immersive nature to each individualized treatment plan, extensive use of simulation in care, and colocation of research capabilities and treatment.⁷¹ The sports medicine, or performance-oriented medicine, approach focuses on lifetime fitness, and returning the amputee to the highest levels of military occupation and combat performance. The ARCs utilize unique clinical treatment, clinical technology, rehabilitation, and research. All of this would not be possible without DoD's dynamic network of collaborations and partnerships.

2.3 COLLABORATION

Over time, DoD has developed a complex ecosystem of collaborations that supports and enhances its efforts toward delivering and advancing state-of-the-art amputee care. This network of collaborations includes the VA, academic institutions, and civilian organizations, reflecting both inter- and intra-agency partners. The inclusion of such entities also demonstrates significant collaboration across and within various disciplines, including those not traditionally associated with health care, such as the technological and material sciences.¹² Maintaining, enhancing, and in some cases formalizing these collaborations will be crucial to sustaining and continuously advancing amputee care.

The DoD approach to care is enhanced by a strong spirit of collaboration, not only as embodied by the integrated multidisciplinary care teams discussed earlier, but also through significant teamwork and partnership both within and across different disciplines. Providing and advancing amputee care requires collaborations to include areas of science not traditionally associated with health care. "Clinicians must clearly identify and communicate the functional needs of patients to engineers, biologists, computer scientists, and systems engineers to achieve common goals."^{12(p xiv)} Furthermore, collaboration with federal, public and private agencies, and academic institutions is integral to the DoD approach to research and care. These collaborations are not replicable and are developed over time.

DEPARTMENT OF VETERANS AFFAIRS

The long-standing and multi-faceted collaboration between DoD and the VA is critical to both Departments' continued commitment to providing lifelong care to traumatic amputees wounded on active duty. As such, the collaboration must be "preserved and cultivated."^{12(pxiv)}

Both DoD and the VA are complemented and enhanced by a variety of partnerships with private, academic, and community-based civilian organizations. A particular strength of the VA system



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is its long-standing formal collaboration with academic institutions, which has produced a rich research culture and capabilities. The VA's 1946 Policy Memorandum No. 2 formally established those partnerships with medical and associated health professions schools across the United States, which have developed into "the most comprehensive academic health system partnership in history."⁷²

These partnerships are overseen by a formal shared governance structure, called a Dean's Committee, and involve shared clinical and research personnel and resources. They have contributed to not only the growth of the VA research enterprise but also to advances in clinical care. Affiliation agreements exist for more than 1,800 colleges and universities spanning more than 40 disciplines and more than 100 schools of medicine.⁷³ Thus, the VA has contributed to training physicians and other health professionals nationally, providing a level of cultural competency in caring for the military that continues throughout their careers.⁷⁴ Although less than half of the 22 million Veterans receive care in the VA system, 45,000 amputees receive their care in the VA system, thus directly benefiting from the availability and depth of VA's health care assets.

Despite the strong DoD-VA relationships, significant differences between the two organizations are important to note, particularly in their respective patient populations. The VA's amputee population is much larger than that of DoD (at more than 45,000⁷⁵ versus just more than 1,600 from OEF/OIF/OND). In Fiscal Year 2013 alone, the VA provided about 35,000 amputation care clinic visits and 1,700 telemedicine visits, and performed more than 7,600 amputations.⁷⁵ However, the majority of amputees receiving care through the VA are 65 years of age and older; much older than the young adult traumatic amputees of OEF/OIF/OND, who have greater athletic capacity compared to the average VA amputee. Additionally, the VA's amputee population has largely sustained amputation(s) related to chronic disease, such as diabetes or peripheral vascular disease, with only 12,502 of VA's amputations being Service-connected and very few as a result of traumatic injury.^{39,75}

The differences in need between the DoD and VA amputee populations are significant, which influences the culture of care of each Department.⁷⁵ Although 80 to 90 percent of DoD amputee patients receive some of their care from the VA, many also return to DoD for ongoing prosthetic care, likely at least in part because of the strong relationships developed between the patients and DoD prosthetists.¹⁶ Those amputees remaining on active duty may choose to seek care from both DoD and VA providers and may choose the VA because of the closer proximity of VA services through its decentralized national system of care and contracted services.¹²

OVERVIEW OF THE DEPARTMENT OF VETERANS AFFAIRS AMPUTEE CARE

The VA has historically been a major provider to veterans with amputations. However, "too often in the past, the VA has taken a narrow view of amputation care, focusing only on managing prosthetic devices,"^{76(pvii)} often to the detriment of the multiple other aspects of amputee care. Recognizing opportunities for improvement, the VA in 2007 increased its attention and commitment of resources to enhance and expand its amputee care program, in part as a result of lessons learned from DoD's paradigm shift to more comprehensive amputee care.³⁹ As a component of this effort, the agency conducted the Survey for Prosthetic Use, a national survey of Vietnam and OEF/OIF/OND Service members and veteran amputees. Additionally, an



external expert panel was engaged to advise the VA on amputee care in light of the distinctive amputee cohort coming out of the current conflicts and DoD's paradigm shift in amputee care.⁷⁶

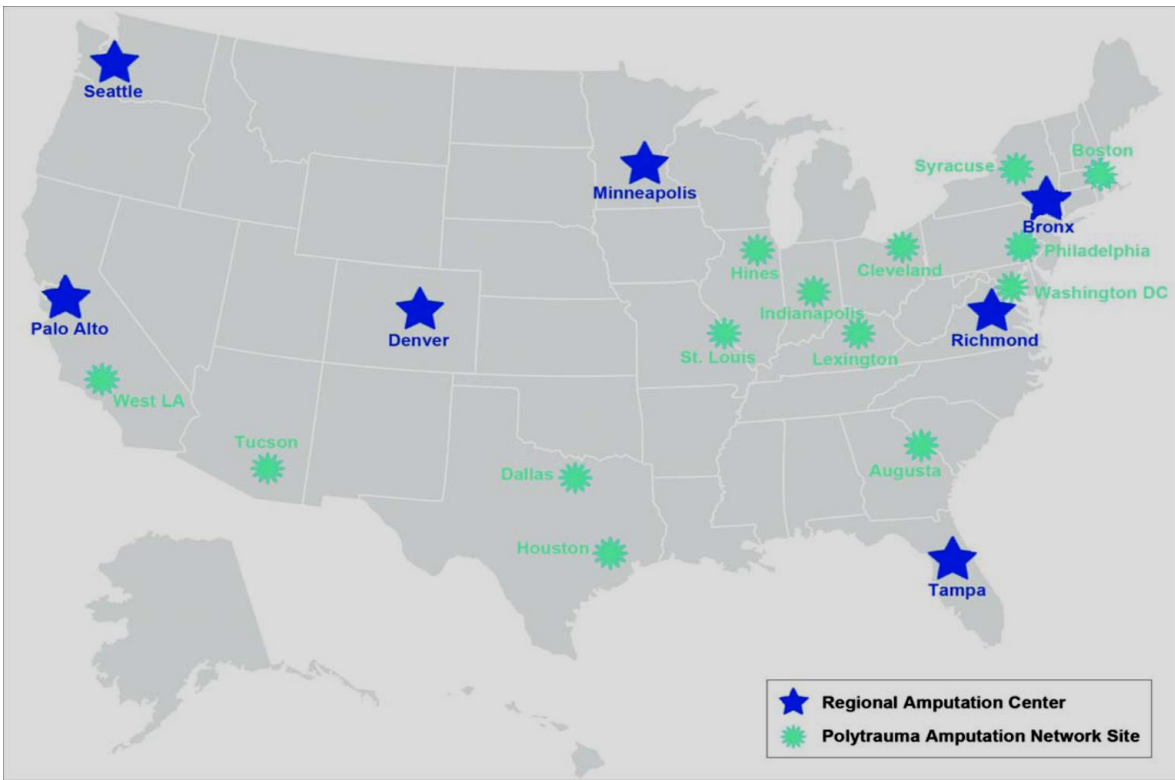
The VA's Amputation System of Care (ASoC), approved in 2008 and funded in 2009, was intended to transform care for all amputees receiving care through the VA.³⁹ In 2010, the VA articulated a vision for its new ASoC, describing a restorative, person-centered, lifelong care model delivered by an integrated, interdisciplinary team.³⁹ The vision noted that care "must be evidence-based, comprehensive, and holistic,"^{39(pxvi)} and focused on "maximizing function, community integration, and participation."^{39(pxvi)} The agency invested more than \$36 million in the ASoC between 2009 and 2013.⁷⁵ The system is designed with tiered centers to combine geographic distribution and accessibility with the expertise and concentration of highly skilled providers, facilitated by an integrated use of telemedicine.³⁹ The system, in alignment with the overarching VA health care system, is divided geographically into Veterans Integrated Service Networks (VISNs).

The VA ASoC's highest level of clinical care expertise is provided through seven Regional Amputation Centers (RACs), which provide the most complex care to amputees as well as training and support to providers in more geographically dispersed locations using telehealth.³⁹ The RACs also actively participate in research, including clinical trials of new technologies.³⁹ The next tier of care in the ASoC is provided by the 18 Polytrauma Amputation Network Sites (PANS) located across the country, which provide the full range of clinical and ancillary services, including prosthetics, and support remote patients and smaller VA facilities.^{39,75} Twenty-two of the 25 RACs and PANS are accredited by the Commission on Accreditation of Rehabilitation Facilities (CARF); the VA plans to have them all CARF-accredited by 2016.⁷⁵

The next tier of care providers, Amputation Care Teams (ACTs), are located at more than 100 small VA facilities distributed across the country to enhance access to care in rural areas.³⁹ They do not have the full range of amputee care and associated services and are generally not CARF accredited.³⁹ The ACTs rely on telehealth support from and referral to the larger RAC and PANS facilities.³⁹ Finally, Amputation Points of Contact (APOCs) are designated providers (usually nurses or social workers) who are knowledgeable about the amputee care system and provide information about how to access amputee care services and support within the VA. These APOCs are embedded within small VA health care facilities that do not have the ability to provide amputee care.³⁹ Additionally, a large number of VA-contracted private sector services complement the VA facilities infrastructure. While the VA has 79 orthotic and prosthetic services, it also contracts with more than 600 additional partners.⁷⁵ Figure 7 displays the geographic disbursement of the VA's RACs and PANS across the United States.



Figure 7. The VA’s Regional Amputation Centers and Polytrauma Amputation Network Sites in new Department of Veterans Affairs Amputation System of Care³⁹



From Sigford, 2010.1(pxvii)

The VA’s diverse system of sites, with varying levels of care among the agency’s facilities and private contracted providers, offers amputees the opportunity to receive care across the country. However, such a network makes transitions and coordination among individual providers (e.g., prosthetist, physical therapist, occupational therapist) more segmented and siloed, as the private sector is not set up to encourage information sharing and coordination among providers. In an attempt to ease these transitions as well as those between DoD and the VA, the VA’s ASoC includes a case management program that prioritizes close provider-to-provider communication.³⁹ Despite these efforts, the VA recognizes that the amputee’s experience of care is still often disjointed, siloed, and lacking in smooth transitions.⁷⁵

The information that the Health Care Delivery Subcommittee has reviewed and the testimony it has heard indicate that, while high quality, the VA’s care does not offer the same intensity and level of care provided by the DoD ARCs for the highly active and ambitious amputee population coming out of the current conflicts. The treatment provided by the VA continues to improve; however, the state-of-the-art rehabilitation and prosthetics care in addition to the comprehensive multidisciplinary teams provided by the ARCs have not yet been achieved in the VA. VA leaders express concern over the image of VA amputee care among the amputee community,⁷⁵ and an objective review of the VA’s prosthetic services published by the VA Office of the Inspector General (OIG) in 2012 found areas for improvement. The report notes that “[w]hile some veterans reported receiving excellent care at VA facilities, many veterans indicated that



[the] VA needed to improve care.” Specifically, “concerns with VA prosthetic services were centered on the VA approval process for fee basis^d care or VA contract care, prosthetic expertise, and difficulty with accessing VA services.”^{35(pv)} The VA’s OIG report was immediately followed by a congressional hearing focused on optimizing care for veterans with prosthetics.⁷⁷

As DoD and the VA will both continue to provide amputee care to Wounded Warriors, understanding DoD’s scope of care and how DoD chooses to intersect with the VA will be important. Historically, this intersection was relatively clear, since DoD did not provide rehabilitative care. However, in recent years DoD has expanded the scope of its care to include this care in its mission. This expansion has blurred the line between the scopes of VA and DoD care. It is paramount that DoD lead in redefining boundaries of the DoD-VA collaborative partnership to accommodate DoD’s expanded expertise in amputee care.

DEPARTMENT OF DEFENSE AND DEPARTMENT OF VETERANS AFFAIRS COLLABORATION

The relationship between DoD and the VA has evolved over time, stimulating collaborative learning that has accelerated the advancement of amputee patient care. One area of collaboration that is critical to the experience of each amputee is the transition of individual amputees from DoD to VA care after discharge from active duty. Both Departments have made significant efforts to facilitate this transition by providing VA staff access to the DoD ARCs, with the specific intent of ensuring that all amputees understand the benefits for which they are eligible and how to enroll for those benefits. This effort, coupled with recognition of the extensive health care needs of amputees, has resulted in higher than average enrollment rates among amputees in VA care compared to other veteran groups. The VA reports that 99 percent of traumatic amputees enroll in VA services within five years of discharge from active duty.³⁵ However, despite the agencies’ efforts, this remains a particularly challenging transition from the amputee’s perspective. This is confounded by electronic medical record systems that are not technologically compatible and do not share patient information.⁶⁶ The transition also comes at the same time that the amputee is experiencing other health and social stressors related to severe injury, such as the transition home, and re-entry into his or her community.

Through its congressional mandate, EACE is tasked to play a lead role in fostering and coordinating DoD-VA collaborations. To this end, EACE encourages and facilitates communications across DoD’s and the VA’s amputee care systems, together entitled “the Federal Amputation System of Care.” EACE has initiated a Federal Amputation Interest Group (a listserv of interested DoD and VA amputee care professionals), embedded web cameras within EACE and each of the ARCs, and coordinates monthly teleconferences among EACE, the ARCs, and the RACs.⁵ Additionally, DoD and VA clinicians have the opportunity to participate jointly in training and education, including conferences and bimonthly DoD-VA virtual amputation care and rehabilitation grand rounds,^{5,39,78,79} and some VA clinical staff are placed at or rotate through the ARCs. DoD and the VA have also jointly developed clinical practice guidelines for the treatment of lower limb amputees, and are developing clinical practice guidelines for upper limb

^d Fee-basis care is a means for providing non-VA care to an eligible veteran when he or she requests to continue receiving care through his or her preferred prosthetist.³⁵



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amputees.^{39,78,79} The two Departments have been working for several years to establish a shared DoD-VA registry of amputee patients and relevant associated data, and hope to have a proposed course of action for initiation within the first half of 2015.⁷⁸

EACE was established with joint DoD and VA leadership that includes a DoD director and a VA deputy director. DoD, VA, and EACE leaders meet monthly via teleconference, and three times each year in person.³⁹

DoD and the VA also collaborate on research efforts. For example, through a partnership between DoD and the VA, WRNMMC Physical Medicine and Rehabilitation residents participate in research activities with the VA Rehabilitation Research and Development Service,¹⁵ and EACE has participated in and led multiple research collaborations between DoD and VA researchers. Of note, the VA's collaborations with DoD include the recent clinical trial of the DEKA Research and Development Corporation (DEKA) arm to study use optimization in collaboration with the Defense Advanced Research Projects Agency (DARPA). This work ultimately resulted in U.S. Food and Drug Administration approval of the device.⁸⁰ Additionally, EACE has participated in developing the VA-DoD Collaboration Guidebook for Healthcare Research, intended to facilitate collaboration between DoD and VA researchers.⁵ EACE is also involved in a VA-led Integrated Product Team through which it is proposing a trial volume purchasing and centralized distribution of artificial limbs for DoD and the VA.

Since 2004, DoD has partnered with the VA, academia, and industry to create a symposium series to bring together leaders in the field to facilitate and accelerate the translation of research into clinical practice.¹⁵ The first Federal Advanced Amputation Skills Training Symposium (FAAST) took place in July 2014, providing DoD and VA providers with the latest tools and techniques in amputee-related care. EACE also provides regular joint DoD-VA updates to Congress on amputee care.⁵ Additionally, both MATC and C5 have engaged in Joint Incentive Funding (JIF) projects with the VA in different areas of amputee care.^{78,81,82} Additional information about other DoD-VA collaborations as summarized by EACE is provided in Appendix G.

ACADEMIC CENTERS AND CIVILIAN PARTNERS

In addition to their partnership with the VA, the ARCs rely heavily on their public and private partnerships to enhance and expand care. Contracts with private businesses add expert staff, such as prosthetists to care teams; fill gaps; provide flexibility to increase, decrease, or change staff in response to ebbs and flows in patient load or changing patient needs; and provide advanced technology and equipment that would not otherwise be available, such as the CAREN and the latest innovations in prosthetic and orthotic devices. Through close communication among providers, contractors, and businesses, this technology is iteratively and rapidly innovated in response to ongoing feedback and requests from amputees.

To meet diverse interests and provide challenging, engaging, and enriching experiences for amputee patients, the ARCs are indebted to their public and private community-based partnerships that enhance rehabilitation and reintegration via recreational and sports activities for the Wounded Warriors. Some of the popular activities provided through these partnerships at one or more of the ARCs include kayaking, fishing, surfing, and shooting range experience.



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One particularly prized partnership is that with the Amputee Coalition, a not-for-profit advocacy group. This collaboration, initiated by WRAMC at the start of OEF/OIF/OND, established a peer visitor program that is now implemented with varying degrees of success at each of the three DoD ARCs.⁸³ The Amputee Coalition's peer support program includes training for amputee peers as well as *Train the Trainer* training for ARC providers, so that the peer visitors are identified and trained on an ongoing basis within each ARC.⁸³ The Amputee Coalition continues to provide trainers and peer visitors with ongoing educational opportunities as well as educational and resource materials for amputees receiving peer visitations.⁸³

The ARCs have also found it vital to establish collaborations with institutions, practitioners, and researchers in areas that are not typically associated with health care, such as engineering, material sciences, systems engineering, and computer science. These collaborations were critical from the very beginning when providers at WRAMC, having little to no experience with traumatic amputees, needed to be trained and prepared for what to expect and how to deliver care for amputees coming back from OEF and OIF. At that time, academic institutions, researchers, and providers came forward and offered intensive training to prepare the providers.

Over the course of the conflict, collaborations with academic institutions and other public and private organizations have fostered invaluable research advances such as development of outcome measures, evolved understanding of clinical needs, and identification of best practices in care. Others have led to transformational advancements in technology and equipment. A summary of select research efforts and accomplishments is described in further detail in the Research Efforts section below.

Without its multiple collaborations, DoD would not have attained the current heights in amputee care. Each component within this dynamic ecosystem of collaborations will continue to be critical in sustaining the current level of care and advancing the science and technology needed to provide state-of-the-art care for amputees in the future. Such a network of relationships and collaborations cannot be replicated, as it is organic in nature and develops over time. Therefore, it will be important to protect and continue to foster this network moving forward, strengthening existing partnerships, and broadening the scope and variety of collaborations. The VA offers a valuable model in its long-standing formal agreement of more than 60 years with academic medical centers, connecting more than 100 schools of medicine with the VA. Implementation of an extramural funding mechanism such as that currently in place at the VA would help DoD foster additional collaborations in the future. For instance, while schools of engineering do not have a direct relationship within the current umbrella VA agreement, engineering schools should be included in any such agreement undertaken by DoD in the future.

Finding 6: Collaborations with institutions, practitioners, and researchers across a variety of disciplines and organizations are critical to DoD's sustainment and advancement in the field of amputee care.

Recommendation 6: DoD should implement formal funding mechanisms and relationships that institutionalize collaboration between DoD and a broad reach of academic medical centers, health care systems, engineering schools, and other institutions important to advancing amputee care.



2.4 RESEARCH EFFORTS

In concert with a strong network of collaborations, an active research program is essential to support and sustain state-of-the-art amputee care.^{15,84} DoD is engaged in research across the spectrum of amputee care. Two critical components of DoD's research efforts in this area are the embedded and integrated nature of research within the clinical setting and the rich network of relationships and collaborative research efforts that bring the Department together with VA and public and private sector researchers.

The DoD ARCs engage in research, both through having their clinicians conduct research, and by embedding researchers in the clinical setting. This colocation and frequent face-to-face interactions between researchers and clinicians foster robust communication and strong relationships, providing an environment rich in creativity where iterative and rapid cycle translation of research into practice is accelerated. Patients provide immediate feedback to providers regarding frustrations with and limitations of equipment, which is passed directly on to the researcher. For example, when a patient quickly breaks a new prosthetic model, this information is provided to the manufacturer immediately to inform improvements. Once the device has been modified, it is again provided to the amputee for use and feedback.

The ARCs and their patients also benefit from the integration of technology and tools normally used for research purposes into the clinical setting. For example, in partnership with the VA, the Naval Health Research Center uses its CAREN system for pre- and post-testing in a fall prevention and recovery study, training lower limb amputees on a specialized treadmill to "recover from a perturbation strong enough to cause a fall."^{85(p5)} Preliminary findings from this study demonstrate "decreased falls [and] increased ability to recover from falls."^{85(p5)} Another example is the gait laboratory, where gait measurement data are gathered and analyzed from traumatic amputees as they walk on sensor plates and are tracked with cameras. The information gathered through these data is then provided to patients, providers, and prosthetists to inform treatment, rehabilitation, and prosthetic selection and adjustment as well as inform research on gait relevant to prosthetic and orthotic development.

Research efforts range across the spectrum of care, including areas such as pain management, prosthetic and orthotic development, limb salvage as an alternative to amputation, and rehabilitation approaches. Standardized data collection and sharing across the three ARCs enhances research activities and facilitates the development of measurement tools. Challenges remain in this area; however, the three centers recognize the importance of sharing data and continue to strive for improved processes toward this end.

KEY DEPARTMENT OF DEFENSE AGENCIES IN AMPUTEE CARE-RELATED RESEARCH

Multiple other DoD agencies conduct or fund amputee care-related research, including congressionally mandated research undertaken by DoD agencies, the VA, and other public and private entities. Most notably, the Telemedicine and Advanced Technology Research Center (TATRC), under the U.S. Army Medical Research and Materiel Command (USAMRMC), and DARPA perform cutting-edge research crucial to the field of amputee care.



As one component of its mission, TATRC conducts medical investigations and information gathering to address gaps otherwise under-addressed in the Department's medical research portfolio.⁸⁶ One of TATRC's programs focuses on advancing amputee- and human performance-related research.⁸⁶ Additionally, within its Biological Technologies Office, DARPA has three programs focused on research areas particularly relevant to different aspects of amputee care and quality of life. These include advancing neural interface technology to control dexterous functions; advancing prosthetics, specifically increasing functionality of the DARPA arm; and improving understanding to enhance brain modeling and interface with the brain to accelerate injury recovery.⁸⁷

THE BADER CONSORTIUM

As previously discussed, DoD's research is often conducted in partnership with and complemented by other agencies conducting research in various fields related to amputee care. The Bridging Advanced Developments for Exceptional Rehabilitation (BADER) Consortium is central to the ARCs' research capabilities and current efforts. The BADER Consortium is a non-profit organization funded primarily by the Congressionally Directed Medical Research Program (CDMRP), as well as Orthopaedic Research Clinical Consortium Award (ORCCA) and Peer Reviewed Orthopaedic Research Program (PRORP), to work with the three ARCs and the Naval Medical Center Portsmouth "to strengthen and support evidence-based orthopaedic rehabilitation care that results in optimal functional outcomes for each Wounded Warrior."⁸⁸ The sole mission of the BADER Consortium is to establish, foster the development of, and achieve sustainability of robust research capabilities within the ARCs. To this end, it establishes partnerships with research leaders such as the Mayo Clinic, Spaulding Harvard, and the University of Delaware, and facilitates the establishment of research partnerships between the ARCs and public and private institutions.⁸⁹ The Consortium also aids the ARCs in identifying research funding opportunities and grant proposal development and provides the ARCs with staff augmentation as well as technical support.⁹⁰

Although the ARCs' research capabilities are significantly enhanced and facilitated by the BADER Consortium, the Consortium must be self-sustainable by September 2016, as it was established with five-year funding in September 2011. Additionally, fiscal constraints and the drawdown of troops from the recent conflicts threaten to diminish medical research funding.⁹¹ Thus, research initiatives that have made significant strides in advancing the field are at risk of being halted mid-course before new advances make it to market or implementation.

2.5 NATIONAL AND INTERNATIONAL AWARENESS

The care of amputees is a national and international need, reaching far beyond DoD. Civilian amputees, in addition to 1,500 infants born each year in the United States each year without fully formed limbs,⁹² create a need to continuously advance the field of amputee care. DoD has attained unparalleled care for traumatic amputees and spurred significant advancements in multiple fields related to amputee care and quality of life. The ARCs have already begun to serve as centers of excellence in several ways beyond the original intent of providing for DoD's traumatic amputees. ARCs patients have included both veterans in the VA health care system and civilian patients through Secretarial Designee status requiring amputation because of chronic disease.⁶⁶ Post-event support after the Boston Marathon bombing, which resulted in several



traumatic amputees who were otherwise young and healthy and similar to amputees from the current conflicts in Iraq and Afghanistan, is one way in which DoD's traumatic amputee care lessons and advances have informed civilian care.^{34,71} In January 2015, the *Boston Globe* published an article that shared the story of two survivors of the Boston Marathon Bombing who, after months of unsuccessful treatment, met with and were evaluated by MATC physicians. They received Secretarial Designee status, and were able to receive care for their injuries at MATC.⁹³ Despite the many publications produced by ARC practitioners and efforts to inform and support national and international amputee care, one clear message heard by the Subcommittee is that further formal documentation and dissemination of what has been learned is essential.⁸³ This would prepare DoD to provide state-of-the-art amputee care in the event of a future conflict, while also improving care for current and future amputees across the Nation and around the world.

In the international context, a huge number of amputees, including traumatic and medical amputees, are in need of advanced amputee care. While the majority of amputations worldwide are related to diabetes and vascular conditions, land mines and ongoing conflicts in many countries cause blast injuries while civil and international conflicts result in thousands of traumatic amputees each year. For example, a retrospective study found that out of 661 amputations that occurred in Lebanon during 2007, 12 percent were due to traumatic injury, 59 percent due to diabetes, and 18 percent due to vascular disease.⁹⁴ Despite these estimates, there remain significant challenges respecting the accurate reporting of amputation data. Thus, it is difficult to assess the total number of amputations that occur, and how many of those amputations are traumatic.⁹⁵ With such international need, several foreign countries, including Georgia and Iraq, have modeled their own amputee care programs after the ARCs' standards of excellence.⁶⁶ Additionally, the ARCs have assisted in the creation of amputee programs in other countries around the world, such as Singapore, by sending ARC providers overseas. Finally, six Georgian nationals were brought to the United States and received care through the ARCs. DoD also hosts foreign students at the ARCs for training in best practices in amputee care.⁶⁶

In sum, the DoD ARCs are positioned to be not only national, but also international leaders in amputee care. If DoD's mission allows, the unparalleled care that the ARCs provide could be made available more broadly to traumatic amputees across the United States and potentially, at least on a selective basis, around the globe. The current process in which patients who are not DoD beneficiaries are allowed to receive care within the MHS requires them to obtain Secretarial Designee status. This process is functional for small numbers of patients; however, it may be cumbersome for large numbers of patients. As the current conflicts wind down, the Assistant Secretary of Defense for Health Affairs has declared expanding the Department's global health engagement strategy as one of six strategic lines of effort.⁹⁶ Such an international initiative would not only generate good will and improve the lives of many in need, but, if deemed feasible to provide care for foreign nationals at the ARCs, may also have the potential to provide DoD practitioners access to the patient load necessary to sustain their skills and expertise.

Finding 7: DoD has established national and international partnerships that have the potential both to benefit amputee care in the military and civilian communities and to ensure ongoing access to amputees to maintain critical military readiness and amputee care skills.



Recommendation 7.1: DoD should continue, sustain, and grow amputee care partnerships on both the national and international levels.

Recommendation 7.2: DoD should establish a national and international telehealth center of excellence capability that promotes consultative partnerships and access to excellent care for amputee patients.

Recommendation 7.3: DoD should maximize the provision of care for civilian traumatic extremity injury and amputation patients and explore the feasibility of, where appropriate, providing care to international amputee patients in the ARCs to bolster case flow.

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3. THE DEPARTMENT OF DEFENSE'S APPROACH TO AND SYSTEM OF AMPUTEE CARE

"The world class amputee care combined with the courage and resilience of members of our armed forces has led to unprecedented levels of performance by this generation of combat wounded amputees."

General Frederick Franks, U.S. Army (Retired)
Class 1966 Chair, Simon Center for Professional Military Ethic, U.S. Military Academy at West Point Commander, VII Corps, Desert Storm, 1991
Commanding General, U.S. Army Training and Doctrine Command, 1991-1994

The Department of Defense (DoD) has shifted the paradigm of amputee care and rehabilitation through the transformation of its approach to caring for and rehabilitating its young, otherwise healthy, physically fit, traumatic amputees over the course of the current conflicts. In contrast to past problem- or injury-focused care, the vision for care that has emerged is multidimensional and dynamic in nature. Research and lessons learned are rapidly implemented in practice, continuously evolving as Wounded Warriors, their family members, and providers elevate the approach to comprehensive treatment through synergistic relationships. These key elements of DoD's culture and vision for amputee care, as described in this section, reflect the culmination of the lessons articulated to date and provide a foundation to inform future developments and continued improvements.

Central to DoD's amputee care approach are the three Advanced Rehabilitation Centers (ARCs), where acute surgical care and intensive rehabilitative care are provided. While the three ARCs share common core tenets in their approach to care, their staffing, budgeting, and historical patient loads vary significantly.

3.1 THE CHARACTER OF MILITARY PATIENTS AND THEIR FAMILIES

The extraordinary character and will of the amputees and their families are indispensable components of the achievement of unprecedented positive outcomes. The motivation, determination, esprit de corps,^a perseverance, and attitude of the amputees and their families has shaped and revitalized the quality of care provided by DoD.

The Subcommittee met and spoke with Wounded Warriors who had experienced amputation and/or limb salvage as a result of traumatic injury while on active duty as well as their family members. These young, otherwise healthy, extremely fit, and high-performing individuals have been consistently recognized by providers for their high intrinsic motivation.¹⁴ The *esprit de corps*, a pervasive force throughout the military community, inspires members through a sense of team or family identity.⁹⁷⁻⁹⁹ Often, the Wounded Warriors are driven to push themselves to recover faster and more fully than thought possible, with the ultimate goal of returning to their units and supporting their fellow Service members in combat.¹⁴ The Subcommittee heard during briefings that the high patient motivation achieved through peer support also tends to improve patient outcomes.



Amputees further along in the recovery process can also provide motivation and hope to those in earlier phases of recovery.^{100,101} Simply having a number of Wounded Warriors recovering in the same location enhances the therapeutic environment, allowing more recent amputees to witness and bond with others further along in recovery.^{100,101} Additionally, some amputees with the desire to give back to the amputee community volunteer and are trained as peer visitors to provide more formal peer support and information to more recent amputees.^{102,103}

United States Army Staff Sergeant Travis Mills exemplifies the qualities listed above.

On April 10, 2012, United States Army Staff Sergeant Travis Mills of the 82nd Airborne was critically injured on his third tour of duty in Afghanistan by an IED (improvised explosive device) while on patrol, losing portions of both legs and both arms. He is one of only five quadruple amputees from the wars in Iraq and Afghanistan to survive his injuries.

Thanks to his amazing strength, courage, an incredible will to live, the heroic actions of the men in his unit, the prayers of thousands, and all the healthcare providers at the [Walter Reed National Military Medical Center], near Washington D.C., Travis remains on the road to recovery. Every day is a battle, but Travis continues to astound friends and family alike with his progress and with his amazing spirit.¹⁰⁴

Amputee care providers and the Subcommittee have observed that the Wounded Warriors' family members contribute invaluable to the recovery process, often uprooting themselves from their homes and moving long distances to live in close proximity to the amputee care centers, and actively participating in the Wounded Warrior's treatment and rehabilitation. Family members engage in care sessions, learn how to support rehabilitation, and maintain boundaries to avoid actions that might inhibit or slow down recovery and progress. The Subcommittee heard numerous accounts of family members staying unceasingly by the Wounded Warrior's side throughout the process, helping to navigate through the recovery system, advocating for the amputee to get the care that he or she needed, and providing emotional and familial support that sustained the amputee and kept them motivated. This support is not only important to the Wounded Warrior, but also to the providers. Family members play a key role by actively engaging in and supporting the treatment and recovery of the amputee.

These qualities are evident in the story of Jay Raffetto, a Marine who sustained a triple amputation during a combat deployment. Jay Raffetto joined the Navy in 2006. After completing basic corpsman training, he volunteered for Special Amphib Recon Corpsman (SARC) training and joined the fleet at Camp Pendleton in 2009. He deployed to Afghanistan in May, 2010. In August of 2010, Jay stepped on an improvised explosive device while on patrol, losing both legs above the knees, his left arm above the elbow, and three fingers on his right hand. Jay received treatment at Walter Reed and the Military Advanced Training Center (MATC), while his family and community gathered to support him during his recovery. Marines from all over the country flew in to be with Jay, while community organizations such as the Semper Fi Fund provided additional emotional and monetary support. Jay and his family were impressed with the treatment they received at MATC; the health care provider teams were supportive and positive while providing state-of-the-art care. After a long rehabilitation process,



Jay and his wife, Emily, have returned to their daily lives. Jay's recovery and successful return to daily life would not have been possible without the high-quality care he received at MATC, the unflagging support of the community and his family, and his extraordinary strength, determination, and positivity. Jay's full story, as told by his father, John Raffetto, can be found in Appendix F.

The Subcommittee heard how patients are fully engaged in their care, pushing their providers and equipment to the limit. They set high goals for their recovery, and work hard toward achieving them, testing the limits of their prosthetic and assistive equipment, and actively providing feedback to providers about equipment-related discomfort or inadequacies. These patients frequently require new technologies to aid them in their recovery process, and actively engage in collaborative decision making to bring the technological advances about. Such innovation requires the full attention of the patients, their families, and their providers. DoD amputee care has been lifted to new heights as a result of the extraordinary character of military patients and support provided by families; these individuals will continue to play a vital role in sustaining and exceeding the extraordinary level of care provided.

3.2 STANDARDS AND CHARACTERISTICS OF THE BEST CARE

Together, the standards broadly defining the best health care or health care system and the specific standards for amputee rehabilitation facilities provide benchmarks and values through which to assess DoD's ARCs.

As defined by the Defense Health Board's (DHB's) National Capital Region Base Realignment and Closure Health Systems Advisory Subcommittee:

A world-class medical^e facility is one where the best of the art and science of medicine come together in a focused effort to meet the needs of the patient by providing the best in physical, mental, social and spiritual care. A world-class medical facility routinely performs at the theoretical limit of what is possible and consistently and predictably delivers superior healthcare value – i.e., high quality care and optimal treatment outcomes at a reasonable cost to the patient and society.^{105(pB-1)}

The National Capital Region Base Realignment and Closure Health Systems Advisory Subcommittee's report defines 18 key characteristics within 6 domains of a *world-class* health care facility (Appendix H). The six domains include basic infrastructure, leadership and culture, processes of care, performance, knowledge management, and community and social responsibility.¹⁰⁵ The report states that to qualify as world class, a "military medical center must meet the requirements for being a world-class healthcare facility but also ensure that it addresses the unique needs of active duty and retired military personnel, as well as the needs of the branch or branches of the Armed Forces served."¹⁰⁵

^e The term "medical" is used interchangeably with "health care" by the National Capital Region Base Realignment and Closure Health Systems Advisory Subcommittee of the Defense Health Board in its report.¹⁰⁵



Defense Health Board

In a 2013 report, the Institute of Medicine (IOM) recommended that providing the best care at a lower cost is both critical and achievable through *continuously learning health care systems*. A continuously learning health care system is defined as “one in which science, informatics, incentives, and culture are aligned for continuous improvements and innovation, with best practices seamlessly embedded in the care process, patients and families active participants in all elements, and new knowledge captured as an integral by-product of the care experience.”^{106(p136)} The seven characteristics of a continuously learning health care system are described in Appendix H. “The path to achieving the vision of a learning health care system entails generating and using real-time knowledge to improve outcomes; engaging patients, families, and communities; achieving and rewarding high-value care; and creating a new culture of care.”^{106(p19)}

The Joint Commission provides certification to many disease-specific care programs, including those focused on amputee rehabilitation.¹⁰⁷ To receive certification, a program must demonstrate “a systematic approach to care delivery and a commitment to performance improvement through ongoing data collection and analysis.”^{108(p1)} These expectations are addressed by (1) “consensus-based national standards, which cover: program management, clinical information management, delivering or facilitating care, supporting self-management, and measuring and improving performance;” (2) “effective use of evidence-based clinical practice guidelines to manage and optimize care;” and (3) “an organized approach to performance measurement and improvement activities.”^{108(p1)} Appendix H details the requirements that must be met to receive and maintain certification, describes areas addressed by these requirements, and provides a general description of the on-site review processes, including application of a patient-tracer methodology, that are used to evaluate and analyze a program’s system of providing care, treatment, and services.

The Commission on Accreditation of Rehabilitation Facilities (CARF) also provides certification for medical rehabilitation facilities that specialize in amputation rehabilitation.^{109,110} CARF’s definition of a person-centered amputee rehabilitation program emphasizes a holistic integrated team approach with the patient as an active member of the interdisciplinary team.¹¹⁰ The full program description is provided in Appendix H.

The characteristics of exemplary care described by the DHB and the IOM, as well as the certification standards of The Joint Commission and CARF, provide a useful framework for assessing the ARCs. The Subcommittee conducted in-depth site visits to each ARC, received extensive briefings from ARC providers and leaders, and visited with Wounded Warriors and their family members. Through this process the Subcommittee witnessed how the ARCs are already providing a very high level of care. However, no formal assessment against the World-Class Health Care Facility specifications or accreditation standards was undertaken by the Subcommittee. It was also apparent to the Subcommittee that the ARCs’ approach to care—like that of world-class and continuously learning health care systems—is dynamic in nature and supports ongoing learning in an extraordinary real-time fashion.

3.3 ADVANCED REHABILITATION CENTERS

DoD has established a new paradigm for amputee care that focuses on ability as opposed to disability, thereby changing its entire framework, focus, and capabilities. Historically, and even today in some amputee care systems, amputations as well as other injuries and illnesses have



been treated from a deficit perspective with the goal of treating the injury and attaining as much basic functionality as possible.¹² However, DoD's current approach to rehabilitative care for amputees is based in sports medicine, pushing patients to the limits of possibility to achieve a return to duty, combat, and active participation in society.

For many of the Service members wounded in combat in the current conflicts, amputee care begins after the explosion of an improvised explosive device or some other traumatic injury. Therefore, unlike traditional medicine, DoD amputee care begins far forward in the field of combat with emergency care being provided by fellow Service members and medics. Beginning this care at the earliest possible time permits application of the most current advances in trauma care in the field, which directly affects the outcomes experienced by combat amputees. The use of tourniquets, staged wound debridement, and stabilization through rapid transport of the injured warrior makes possible continuous amputee care from the field of combat back to the continental United States (CONUS).⁵⁹ During the transition of the Wounded Warrior to CONUS, providers outside the continental United States (OCONUS) work to involve the patient in his or her own treatment plan and initiate early communication to identify the ARC closest to the Wounded Warrior's home and to ensure that a surgical team is available and prepared with information about the Wounded Warrior and his or her injuries.^{59,71} Admission to one of DoD's three ARCs, all located in CONUS, brings the Wounded Warrior to the core of DoD's amputee care model, and begins a complex, intense, and unique treatment and recovery process.

As noted in Section 2, the ARCs were established by DoD to meet the need for rehabilitative care of traumatic amputees coming out of the current conflicts and are the centerpiece of DoD's approach to amputee treatment and rehabilitation. The DoD-Veterans Affairs (VA) Extremity Trauma and Amputation Center of Excellence (EACE) serves as a strategic integrator with the ARCs, facilitating a unified enterprise-wide approach to care in partnership with the VA. Without the ARCs, the current level of care would not be possible because the ARCs "provide clinical expertise that can only be achieved by caring for a high volume of patients"^{12(p xiii)} in "collaboration [with] multiple specialists from a variety of disciplines to develop creative solutions to unique problems."^{12(p xiii)} Creation of the ARCs permitted concentration of patient volume, providers, and other resources. This provided care environments unmatched in any other amputee care system and fostered development of the distinctive care culture and approach in the ARCs.



APPROACH TO CARE

While implemented in different fashion at each ARC, a common vision and approach to care that includes several core characteristics (see Figure 8) is shared among the three ARCs.

The ability-, rather than disability-focused approach is embodied in a truly integrated multidisciplinary team approach, with active engagement of the patient and family throughout treatment and rehabilitation. Care is holistic and comprehensive while being individualized to meet each Wounded Warrior's needs. Researchers are embedded within the clinical setting, intertwining active research with clinical care. Early and aggressive rehabilitation includes extensive utilization of specialized adaptive technological and assistive equipment. Peer support as well as sports and recreation also are vital to the patient's experience and recovery. The culture and approach to care thrive in facilities specially designed to support this dynamic approach and their unique patient populations.¹⁵

Figure 8. Key Characteristics of the ARCs' Approach to Amputee Care as Observed by the Subcommittee

- Integrated multidisciplinary care team
- Active engagement of the patient and family
- Holistic and comprehensive care
- Embedded researchers in the clinical setting
- Early and aggressive rehabilitation
- Extensive utilization of specialized adaptive technological and assistive equipment
- Peer support
- Sports and recreational activities
- Specially designed facilities
- Communication
- Provider Support
- Collaboration

INTEGRATED MULTIDISCIPLINARY CARE TEAM

A truly integrated interdisciplinary team approach with regularly occurring interdisciplinary team meetings is central to DoD amputee care. At each ARC, the components of the team vary somewhat but commonly include physical medicine and rehabilitation, physical therapy, occupational therapy, orthopaedics, prosthetics, nursing, pain management, behavioral health, vocational rehabilitation, peer support visitors, rehabilitation engineers, and case managers.¹² Figure 9 provides a list of key practitioners in the U.S. Army Amputee Patient Care Program care team from 2006, which remains a good representation of the team today. In addition to almost daily interactions among providers, weekly interdisciplinary meetings create the opportunity for providers to share observations, create unified treatment plans, and resolve particularly challenging clinical problems.¹⁵ Team integration is further facilitated in some of the ARCs by physically locating the offices and workspaces of different providers and specialists in close proximity to each other.

The enhanced interaction among providers and specialists creates a seamless experience for the Wounded Warrior, since their multiple care-givers are

Figure 9. Components of the Patient Care Team Within the U.S. Army Amputee Patient Care Program²⁵ (Table 3, p. S189)

- Orthopaedic, plastic, and vascular surgery
- Physical medicine and rehabilitation
- Regional anesthesia and pain management
- Nursing
- Physical therapy
- Occupational therapy
- Prosthetics and orthotics
- Psychiatric consultation and liaison service
- Social work
- Dietetics/Nutrition care
- Public affairs office
- Gait laboratory
- Ministry and pastoral care
- Peer visitation (Amputee Coalition of America)
- VA counseling
- Vocational rehabilitation and employment services
- VA research community
- Red Cross
- Department of Labor

From Potter, et al, 2006.



directly communicating with one another and working synergistically rather than functioning in silos. This collaborative care approach reduces the risk of miscommunication and medical error often associated with poor communication between providers. Additionally, this multidisciplinary communication has led to important advancements in care. For example, interactions between prosthetists and surgeons resulted in the best practice established during the current conflicts of retaining the largest possible skin flap during amputation to cover the portion of the remaining limb to improve prosthetic fitting and comfort. This integrated team approach has positively affected both long- and short-term outcomes among amputees.^{111,112}

ACTIVE ENGAGEMENT OF THE PATIENT AND FAMILY

The Wounded Warrior and his or her family also are actively engaged as members of the multidisciplinary team throughout the treatment and rehabilitation process. A Service member who sustains an injury that requires amputation or limb salvage efforts is assigned to one of the three ARCs as his or her place of duty during treatment and rehabilitation.^{71,113} During this time the Wounded Warrior's full-time job is to actively participate in the recovery process. The benefit of this approach, one rarely possible outside of DoD, is that the patient can fully focus on recovery for a prolonged period of time, rather than having his or her attention divided among work or income needs, other stressors, and rehabilitation. Even after regaining initial functional abilities, amputees at the ARCs often spend many hours every day participating in care and rehabilitative activities and recovery services.

Family member participation is facilitated by DoD provision of travel and housing support for nonmedical attendants, usually family members, and encouragement of their active participation in the rehabilitation process.¹⁵ Family members often uproot themselves to live in close proximity to the ARC where a loved one is receiving care. Whenever possible, providers involve family members in treatment and rehabilitation activities and discussion so the family will understand of what the amputee is capable and what assistance may be necessary. In this way, informed family members can support and encourage more rapid recovery. In addition to being engaged in the amputee's treatment and rehabilitation, often serving as advocates, family members provide invaluable emotional and psychosocial support to the Wounded Warriors not available through other means.

PEER SUPPORT

All three ARCs place great value on both formal and informal peer support as an aspect of their approach. As discussed in Section 2, each ARC has established (to varying extents) a peer visitor program through which amputees further along in the recovery process are trained and provide peer visits and support to amputees earlier in the process. The Walter Reed National Military Medical Center (WRNMMC) peer support program trains military amputee volunteers to go through training offered by the Amputee Coalition of America to provide specialized support to new amputees. Patients who received visits through the peer support program reported significantly higher satisfaction with treatment than those who did not participate in the program.¹¹⁴ While the program has been well received, the decrease in the number of new amputees and challenges associated with gaining peer visitor access to the patients has decreased participation. In spite of the decreased size of the peer visitor program, Service members continue to visit and support one another, during their inpatient stays. In addition to this formal



program, the informal encouragement, mentorship, and general therapeutic environment generated among peers “creates a healthy therapeutic milieu with immeasurable psychological benefits for patients and their families.”^{12(p xiii)} At the ARCs, newly injured patients recover alongside fellow patients “who may be months out from their injury and working on higher level skills than once thought possible. Witnessing such recoveries firsthand creates a supportive and motivating environment for each patient.”^{12(p xiii)}

HOLISTIC AND COMPREHENSIVE CARE

Each Wounded Warrior’s assessment and treatment plan is comprehensive and highly individualized to address all existing issues simultaneously in an integrated fashion.¹² Patients are involved in setting their own goals for recovery, which then shape the treatment plan to conform with the patient’s interests, injury severity, which limb(s) are amputated and at what level(s), comorbidities, and other needs and circumstances. The multidisciplinary team may vary slightly from patient to patient in order to most appropriately address the individual needs of a particular amputee. However, the inclusion of practitioners from core specialties ensures comprehensive and holistic care that specifically includes behavioral, psychosocial, and recreational types of support in addition to the physical medicine and prosthetic aspects of care.

EMBEDDED RESEARCHERS IN THE CLINICAL SETTING

While the extent of integration and robustness varies among the centers, researchers are embedded within the clinical setting at each ARC. Enhanced by EACE personnel and BADER Consortium technical assistance, each ARC actively conducts research related to amputee care. These embedded researchers allow for accelerated implementation of new discoveries into practice. Within the ARCs, patients and clinicians work directly with researchers to push the limits of technology, driving the field forward.¹² In this way, the ARCs become the place to which others in the field of amputee care turn when seeking best practices and state-of-the-art science. The direct interface between research and clinical care means that new and experimental equipment and technologies are often available to amputees at the ARCs before they reach the commercial market. This also leads to such advances as training on a treadmill to reduce falls related to tripping as well as gait variations and observing the interplay between prosthetics and gait.

Although this close collaboration between researchers and health care professionals has produced promising results, it has not always been deliberate, coordinated, or documented. A formalized process and system for collaboration may provide the infrastructure to support ongoing innovation and allow for the collection of data to determine the success of new treatments.

Finding 8: The ARCs have demonstrated synergy between clinical care and research that provides for the rapid translation of new research advances into amputee care. However, the approach would be better sustained if it were deliberate, documented, and coordinated.

Recommendation 8: DoD should systematize the methodology and codify the current synergy between clinical care and research through targeted funding and strategic use of personnel, particularly with respect to the rapid translation of



research into practice. Based on its charter, EACE is well situated to do this within the MHS, VA, and civilian practice.

EARLY AND AGGRESSIVE REHABILITATION

The ARCs have revolutionized amputee rehabilitation by aggressively integrating it early in the overall care process. Rather than beginning rehabilitation after fitting a prosthetic, or even earlier after surgical procedures are complete, rehabilitation principles are now incorporated by the multidisciplinary care teams at the earliest stages of acute medical and surgical care.¹² This early incorporation of rehabilitation minimizes the negative effects of deconditioning after injury as well as the negative psychological and recovery effects of impaired mobility and lack of independence.¹² The peer environments at the ARCs enhance the rehabilitation experience, where amputees can observe peers who are further along in the process performing activities that they hope to achieve and witness fellow amputees walking for the first time on prosthetic legs before they go through the process themselves.

EXTENSIVE UTILIZATION OF SPECIALIZED ADAPTIVE TECHNOLOGICAL AND ASSISTIVE EQUIPMENT

Each ARC has different variations in equipment; however, each incorporates extensive utilization of specialized adaptive technology and equipment to enhance rehabilitation. Equipment includes devices such as a tidal wave pool that provides a multifaceted rehabilitative exercise for amputees that support both psychological and physical well-being and recovery. The Intrepid Dynamic Exoskeletal Orthosis (IDEO™), an exoskeletal device, transforms rehabilitative opportunities for those with salvaged limbs, enabling Wounded Warriors to walk and even run in cases when walking would be impossible or very limited without the device. A Computer Assisted Rehabilitation Environment (CAREN) is utilized to provide a practice and training platform for Wounded Warriors, allowing the user to maneuver walking and maintain balance on a platform that tilts in multiple directions and interacts with an animated computer environment. Each ARC is also outfitted with a gait laboratory with cameras and force plates in the floor to measure an amputee's gait, thus informing prosthetic selection and fitting as well as care. These examples highlight the extent to which specialized and cutting-edge equipment is used by the ARCs to enhance rehabilitation.

SPORTS AND RECREATIONAL ACTIVITIES

Incorporating sports and recreation into an amputee's recovery process is a practice whose value has been documented historically, and it continues to be a priority in amputee care at the ARCs today.¹² The ARCs' sports medicine model for rehabilitation is striking in its focus on ability, its drive to surpass expectations for care and recovery, and its creative approach that leads to unprecedented discoveries. An amputee's participation in sports and/or regular physical activity has been demonstrated to have a positive effect on physical and psychological well-being.¹¹⁵ Activities vary by ARC depending on the opportunities available in the local environment, the facility, and its partnerships. Activities can include fishing, shooting at a shooting range, and swimming. A surfing program anecdotally accelerated reduction in amputee needs for pain medication, as patients are required to abstain from using pain medication in order to participate in the program for safety reasons.



SPECIALLY DESIGNED FACILITIES

In addition to the sports and recreational activities available in the areas surrounding the ARCs through partnerships with nonmilitary programs, the ARCs also have built extensive facilities to accommodate sports and recreational activities internally. Such facilities and accommodations include indoor tracks with ceiling suspensions, permitting safe and free walking and running practice with suspension ropes to catch falls and hold an amputee upright while he or she regains footing. Areas with multiple types of terrain, as well as slopes and stairs, provide the opportunity to practice walking on surfaces that can be challenging to navigate with prosthetic legs. Climbing walls and swimming pools provide other opportunities for therapeutic recreation.

The facilities include prosthetics laboratories within the clinical care setting, as well as colocation of physical medicine and rehabilitation services. Facilities are designed to enhance the patient experience, increasing peer interaction as well as patient inclusion in the care process. This is exemplified in the Center for the Intrepid's (CFI's) prosthetics laboratory where, while waiting to be seen, amputees observe fellow patients testing new prosthetics and observe the technicians making adjustments and preparing devices through a window from the waiting room that opens into the work area.

These features are key to DoD's amputee care approach; their overlap and interconnections create synergy that expands the value of each individual component. In addition to the key characteristics of the approach, other essential aspects of the ARCs' culture include communication, provider support, ongoing provider education and training, and collaboration.

COMMUNICATION

Communication among providers across the disciplines, the patient, and family members is paramount throughout the treatment process. With regard to surgical decision making and execution, the multiple subspecialties involved in amputation must be in active communication with each other. Additionally, the medical team, rehabilitation team (particularly the prosthetist), and the patient must all be in communication with the surgical team, particularly with respect to planning and decision making regarding amputation versus limb salvage, and limb length if amputation is selected.¹⁵

As noted earlier, communication across the continuum from point of injury to CONUS is critical. Providers in the combat areas and intermediary health care facilities (such as Landstuhl during the current conflicts) communicate with the ARCs to ensure the patient is transported to the most appropriate facility and the provider team at the facility is prepared for the amputee's arrival and anticipates and understands the nature of the injury and patient needs. This often takes the form of a simple telephone call from an overseas provider (often a surgeon or other physician) to a provider within one of the ARCs. Over the years of conflict, providers at the various facilities have developed contacts and relationships that further aid communication. Additionally, providers send paper records, compact discs, and portable memory devices with the patient when he/she is transported to the next care facility and eventually to the ARC. However, since paper records can be misplaced or separated from the patient during transport, providers often write essential medical information directly on a patient's wound dressing to ensure that critical



information is received by the provider team on the receiving end.⁵³ This significantly facilitates the coordination and continuity of care.⁵³

Although amputees are almost always cared for at the ARCs, and are usually based at a single ARC, they occasionally are transferred between ARCs and/or receive care at other DoD medical facilities. For example, this may be necessary if the amputee also experienced severe burn injuries, in which case he or she may receive care at the U.S. Army Institute for Surgical Research Burn Center before transferring to an ARC for amputation care. In these circumstances, and also simply for tracking a patient over a prolonged period of time, it is essential that medical records be accurately maintained. As such, DoD's electronic medical record, which is standardized and globally accessible across DoD's health care system, is utilized for all DoD patients, including amputees.⁵³

In addition to using the forms of communication noted above, providers also rely on other methods of communication for different care-support purposes. Telecommunication or telehealth enables experts at the ARCs to provide support and guidance at a distance to providers less experienced in traumatic amputee care, often in the deployed OCONUS setting or in DoD health care facilities that do not specialize in amputee care. This telehealth support is provided via telephone, video, or sharing of medical imagery for analysis by experts at an ARC.

Patients also participate in and benefit from more active and personal communication with their providers than is often experienced by patients in other health care settings. The Subcommittee heard from patients and providers that social media and text messages were a common way for patients to stay in touch with their providers. Providers noted that often a patient who had been discharged from an ARC would send a text message or send a Facebook message with a question or concern, allowing the provider to give feedback and assist in resolving a problem and preventing an unnecessary visit to the center. In other instances a provider was able to identify potential problems through informal messaging and intervene before the issue became more serious. Patients shared with the Subcommittee that their ability to reach their providers (e.g., surgeons, physicians, prosthetists) in this manner throughout their care and rehabilitation provides much better access and assurance than is available in other health care settings. The diversity of communications enhances awareness and understanding of all parties involved throughout the care process and provides a safety net to prevent patients and their problems from "falling through the cracks."

PROVIDER SUPPORT AND TRAINING AND EDUCATION

Sustaining and supporting the best practitioners in the field is vital, both in avoiding burnout and traumatization as well as in providing for ongoing education, training, and advancement for each provider. Continuing education, including graduate medical education, training of prosthetists, and military-specific curricula, is essential to keeping providers current in state-of-the-art care and available assistive technologies and to maintaining specific skills and knowledge areas.¹⁵ Providers at the ARCs indicate that it is useful to present issues of a cross-disciplinary nature, such as pain management, wound management, and psychological adjustment, in multidisciplinary forums to promote discussion across disciplines.¹⁵ It is also important that educational curricula continuously evolve to keep pace with rapidly advancing approaches to care, be provided often to assess and address providers' needs, and account for frequent staff



turnover.¹² Ongoing education and training also are vital in maintaining medical readiness in anticipation of new conflicts and ensuring that medical staff are properly equipped and practiced in delivering state-of-the-art care.

DoD also often collaborates with the VA and civilian institutions to conduct or participate in training and education. Training and continuing education opportunities are varied in response to the provider needs as well as technology. Such programming takes the form of webcasts; intensive classes, conferences, and symposia; fellowships; and even telecommunications-supported grand rounds across multiple locations.⁵ However, a formalized graduate education program between the ARCs and educational institutions and health systems does not exist. As such, valuable training and collaborative opportunities may be overlooked, and amputee care is not incorporated as well into health care professionals' skills or into developing technologies.

Finding 9: The Subcommittee found that while the ARCs do interface with medical entities and medical training programs, they do not provide residencies, fellowships, or other postgraduate programs.

Recommendation 9: DoD should collaborate with educational institutions and accredited programs to provide graduate and postgraduate training experiences in ARC settings in order to build and maintain provider expertise and ensure health professionals are up to date on the most recent advancements in amputee care.

One area exemplifying the need for real-time education and training is rapid advances in assistive devices and adaptive technologies. The need for frequent training and education of providers on the selection of the correct prosthetic or orthotic device(s) for a given patient has become essential. Experts across the field recognize that training on selection, application, and use of these devices is increasingly important.^{116,117} With many new options and the appeal of accessing the latest devices, it can be challenging for providers to stay up to date with all of the devices becoming available and skillfully identify the best device to match the individual and his or her needs. Thus, the provider must have a thorough understanding of a specific device to provide adequate training to the Wounded Warrior on how to use it to its fullest potential. This is an area that will continue to be important in the future as new devices become available and amputees' activities and bodies change over the course of their lives, creating still more new prosthetic needs.

3.4 MAINTAINING THE MODEL

In addition to understanding the qualitative characteristics of the ARCs and their approach to care, the Subcommittee found it important to understand their resourcing requirements. Costs, staffing, patient load, and productivity are the key areas the Subcommittee considered in terms of resourcing the ARCs. In planning for long-term sustainment of one or more ARCs, it is important to understand the costs and staffing models required to provide high quality care to the patient population in the future.

COSTS

The Subcommittee found it challenging to obtain sufficiently complete or standardized cost information to inform even a basic understanding of the operating costs of the ARCs. While the



ARCs have similar missions and capabilities, their organizational structures are different. These differences may relate, in part, to the dissimilar ways in which they were initially formed and resourced. Each ARC also is aligned under different authorities (the Defense Health Agency National Capital Region [NCR] Medical Directorate, U.S. Army, U.S. Navy), and each Service approaches organizational structure, staffing, and resourcing differently. Therefore, there are inherent differences in the ARCs' organizational structures and staffing models. Further, two of the ARCs (MATC and Comprehensive Combat and Complex Casualty Care (C5)) are embedded within a main hospital facility, while the CFI is a standalone facility. This consideration is likely to lead to different organizational structures and staffing, as well as how square footage, resources, and supplies are counted. Given the lack of standardized cost information, cost comparisons among the ARCs were simply not possible. The lack of standardization and granularity of the cost information collected and reported was further confounded by a lack of clear delineation of responsibility for facilities, equipment, supplies, and staffing shared among the ARCs and other co-located medical facilities.

Experts were able to provide rough estimates of treatment costs per patient for each ARC; however, the data must be interpreted with significant caveats. It was not possible to delineate amputation-related care costs from other care provided by the associated military treatment facility; therefore, the costs for each amputee patient include all health care costs. Additionally, the total cost estimate is incomplete, as Medicare is the first payer for eligible patients who seek private sector care, and any VA care was not included. The costs for prosthetics fittings were included, although the data reflected total costs rather than individual patient costs. Finally, the greatest concern is that the cost data do not take into account the case mix and severity of injury variables.

Finding 10: It is currently impossible to comprehensively determine the cost of DoD's amputee care programs. One cannot determine value without accurate data on cost. Although limited data related to the cost of amputee care exist, these data are not collected systematically or organized for easy access and analysis.

Recommendation 10: DoD should refine its data management systems and processes to allow comparative and comprehensive analysis of the total cost of amputee care.

In Fiscal Year (FY) 2012, CFI operated on an annual budget of \$11.7 million, and in FY 2013 its annual budget totaled \$12.3 million, which was supplemented by \$0.35 million from EACE. Since FY 2012, C5 has operated on a \$6.9 million Defense Health Program-funded annual budget that has been supplemented with an additional \$2.6 million to support prosthetic-related costs.⁶⁸ To augment formal funding streams, the ARCs compete for research funding, which often funds research personnel and if provided by DoD and other federal and civilian agencies.⁶⁷

The patient costs per ARC were commensurate with the number of patients treated at each facility. For FYs 2008 to 2014, MATC treated 1,268 patients, CFI treated 993 patients, and C5 treated 347 patients. The total amputee treatments cost per ARC for FY 2008-2014 was \$409 million at MATC, \$163 million at CFI, and \$33 million at C5. The new patient numbers have been steadily declining as the number of ground troops continues to draw down. Costs and



patient numbers peaked in 2011 at all three ARCs. The latest complete data from FY 2013 indicated roughly \$21.2 million in costs at the MATC, \$10.4 million at CFI, and \$2.7 million at C5. When broken down, these costs averaged \$103,000 per patient at MATC, \$55,000 per patient at CFI, and \$35,000 per patient at C5. There is a significant decline in treatment costs for amputee patients as they move forward through their rehabilitation, with a 33 percent observed decline from the first year to the second year post-injury. A larger decrease of 60 percent was observed from the second year to the third year post-injury. The total cost for amputee care within DoD is now estimated to be less than \$100 million per year and will likely continue to decrease as the new patient load continues to decrease.

Prosthetics are an important and costly aspect of amputee care, particularly with the rapid technological advances of recent years. MATC provided estimated spending per patient by amputation level over the past two years as \$220,000 for below-the-elbow amputations, \$240,000 for above-the-elbow amputations, \$112,500 for below-the-knee amputations, and \$235,000 dollars for above-the-knee amputations.⁶⁴ Table 2 provides MATC's projected prosthetic costs for new prosthetics as well as maintenance of old prostheses. These costs do not account for increasing prices related to advances in technology as well as inflation.⁶⁴

Table 2. MATC Prosthetic Costs for Current and Projected Patients (not corrected for inflation)^{64(pA-7)}

	2014	2015	2016	2017	2018
New^f	\$ 11,647,500	\$ 11,647,500	\$ 9,397,500	\$ 9,397,500	\$ 9,397,500
Maintenance^g	\$ 9,562,625	\$ 11,679,125	\$ 12,449,125	\$ 12,818,625	\$ 13,588,625
Total	\$ 21,212,139	\$ 23,328,640	\$ 21,848,641	\$ 22,218,142	\$ 22,988,143

Adapted from Walter Reed Amputee Patient Care Program: Report to Defense Health Board^{64(pA-7)}

Long-term medical costs and care challenges of sustaining and living with an amputated limb are numerous and generally increase with time.¹¹⁸ The ongoing and increasing expenses of refitting, adjusting, replacing, and prescribing new prosthetics and assistive equipment change as amputees age and technology advances. While there is recognition that such costs are likely to increase significantly, it is difficult to reliably predict how much costs will increase.¹¹⁸ Secondary and tertiary comorbidities associated with limb loss include limited mobility, weight

^f “New” costs indicate costs of new amputees, and are based upon MATC’s current spending analysis per patient by amputation level over the past two years.⁶⁴ MATC’s assumptions state an additional 20 patients will seek a delayed amputation at WRNMMC each year in 2012, 2013, 2014, and 2015, as 3 percent of all battle injuries lead to immediate amputation, and an additional 0.45 percent experience delayed amputation. The average length of time to delayed amputation is 497 days. Additionally, as the conflicts draw down, MATC expects approximately 60 new patients each year from tumors, trauma, training accidents, and disease that are not currently cared for at WRNMMC.⁶⁴

^g Projected maintenance costs for patients discharged from WRNMMC do not include initial care costs, nor potential replacement sockets for each of the complete prosthetic capabilities a patient utilizes (e.g., running, swimming, bicycling). MATC’s assumptions state 50 percent of amputees who initially received care at WRNMMC return every two years for the equivalent of one complete prosthetic replacement. Cost calculations were based on the following: (number of patients treated each year by level of amputation) x (0.5 expected returning for prosthetic care) x (cost for single complete prosthesis). Upper extremity prosthesis assumes myoelectric replacement, and all above-knee prostheses assume microprocessor replacement.



gain, diabetes mellitus, and coronary artery disease, among others.¹¹⁸ Early medical management to address primary health concerns and prevent, decrease, or slow the development of secondary and tertiary health concerns is important in reducing costs to the health care system as well as improving the quality and length of life for individual amputees. These issues are discussed further in Section 4.¹¹⁸

STAFFING

Staffing is a basic, substantial, and critical ARC cost. No standardized staffing ratio or formula exists across the three ARCs for providing care to this unique population. Facility-specific staffing ratios depend on multiple factors, including “patient acuity, experience and expertise of the provider, access to resources, and partnerships with other institutions.”^{15(p 11)} As a result, staffing varies substantially across the three ARCs. However, Appendix I portrays potential staffing ratios for amputee care that were developed by expert consensus and published in 2009. The core team in this matrix includes orthopaedics, physiatry, physical therapy, occupational therapy, recreational therapy, nursing, social work, case management, and administrative support.¹⁵

In 2003, Walter Reed Army Medical Center established a staffing model to meet projected long-term provision of amputee care to its patient population, to include four prosthetists, five physical therapists, one physical therapy assistant, three occupational therapists, and two nurse case managers, totaling 15 full-time equivalent (FTE) personnel.^{64(p4-5)} C5 authorized staffing strength was under review as of the end of 2013, at which point on-site strength was 121 FTEs, including physical therapy, occupational therapy, recreational therapy, case management, physical medicine and rehabilitation, prosthetics, nursing, psychology, neurology, gait lab, pharmacy, and administrative support personnel. CFI’s staffing consists of 41 authorized positions, including occupational therapy, prosthetics, rehabilitation psychology, nursing, occupational therapy, physical therapy, engineering, recreational therapy, information technology, case management, and administrative support personnel which were further augmented by multiple contract and VA personnel.¹¹⁹ Staffing levels and types vary among the three ARCs to meet different patient loads and needs. They also are challenging to interpret because of the different contexts in which each ARC operates. Further, since each ARC shares or benefits from staff from partner or host hospitals or the VA the personnel lists of each ARC do not provide a full representation of the care team and support personnel that serve the ARCs’ amputees.

PATIENT LOAD AND PRODUCTIVITY

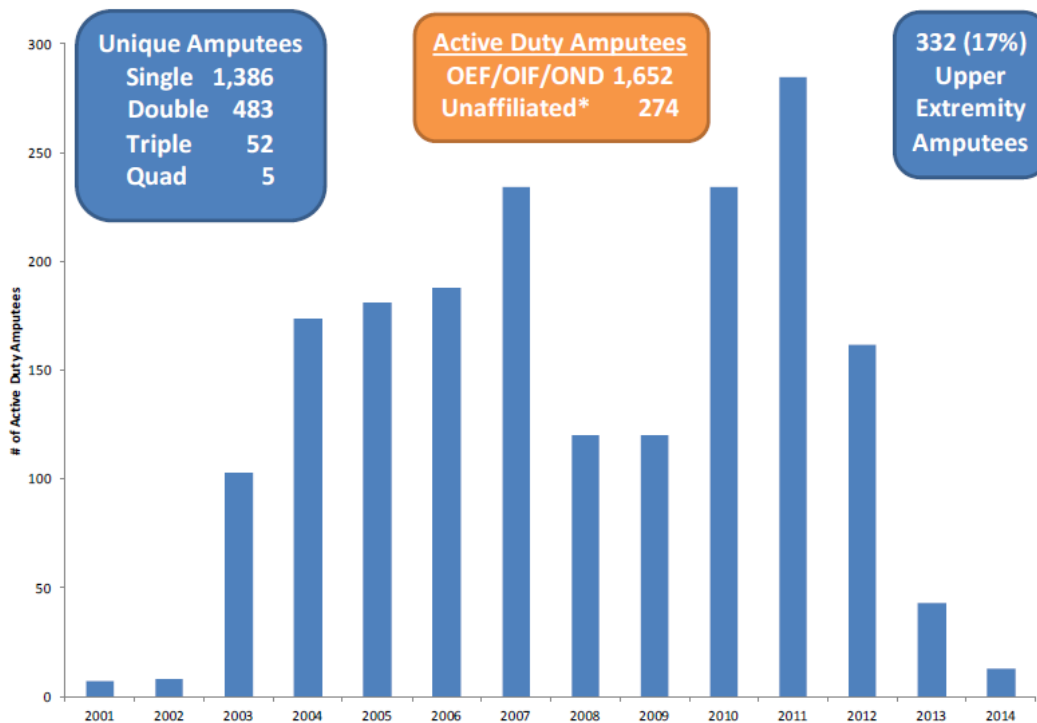
Costs in the clinical setting should generally also account for patient throughput and productivity. However, this too is challenging to assess in the ARCs, as injury severity and complicating factors such as comorbidities or concomitant injuries vary dramatically from patient to patient, and there is no true average length of stay. In fact, length of stay varies from six months to a few years⁶⁹ with varying levels of intensity of care. Therefore, comparisons of the numbers of patients seen or the numbers of visits, without qualifiers and descriptors, do not provide sufficient information to inform cost analysis or comparison. As noted above, the Johns Hopkins Applied Physics Laboratory, in collaboration with C5, developed tools that have enhanced C5’s patient tracking, rehabilitation timeline management, and data reporting



capabilities.⁶⁸ These tools could be useful in providing insight into workload across all three ARCs; however, these tools are not yet compatible with the CFI or MATC Information technology (IT) systems.

The total number of active duty amputees during the current conflicts is described in Figure 10. As of September 1, 2014, 1,926 active duty amputees had received care since 2001, a large proportion of which experienced amputation as a result of blast-related injuries.

Figure 10. Active Duty Amputees¹²⁰



*Unaffiliated Active Duty Amputees are not a Conflict (OEF/OIF/OND) related amputee (i.e., training accident, disease, etc).

Data Source: EACE-R Amputee Database as of September 01, 2014. Excludes finger(s), thumb(s), and toe(s) amputations; includes partial foot and hand amputations.

From Shero, J. 2014.¹²¹

There have been more than 20,000 theater-related extremity injuries in Operation ENDURING FREEDOM (OEF)/Operation IRAQI FREEDOM (OIF)/ Operation NEW DAWN (OND), which includes the 1651 casualties who sustained amputation injuries. The 20,000 extremity injuries include significant rehabilitation cases which may not be amputees, but who receive care at the ARCs. There continues to be “delayed amputations” among the theater-related casualties with extremity injuries. An amputation is termed “delayed” if it is 90 days or longer after the initial injury. The majority of delayed amputations occur within 18 months of the initial injury. However, there have been delayed amputations that occurred more than 10 years post injury.

Blast is noted as the mechanism of injury for a large percentage (86 percent) of the current theater-related active duty amputees. As noted in the Complex Battle Injury Task Force Report,



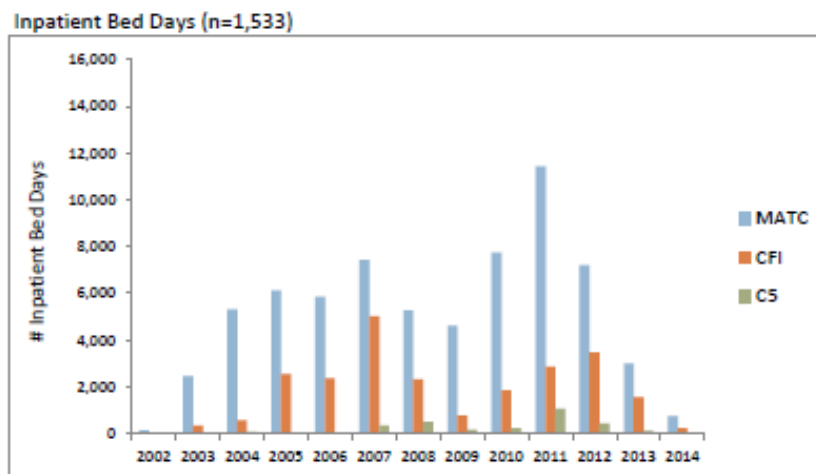
blast-induced amputation is often a multi-limb amputation or a single amputation coupled with a multi-extremity or other injury. These injuries are also likely to be complicated with severe burns, and traumatic brain injury. Genitourinary injury is also common and can have devastating and deeply personal psychological and physiological lifelong impacts on Wounded Warriors and their families¹²² although it is frequently not included in discussion, and there is scant scientific literature with regard to treatment.¹²³ Military medicine has evolved to manage the immediate and near-term medical needs of this population. However, their long-term medical and rehabilitation needs are largely unknown.

Upper extremity amputation presents a significant disability and is represented in 17 percent of the military amputee population.¹²¹ Upper extremity amputations often result in a greater decrease in ability to accomplish activities of daily living and are a more visible, psychologically impactful amputation than lower extremity amputations. Additionally, the upper extremity amputee population is highlighted to show the number of casualties who may potentially be candidates for hand transplantation.

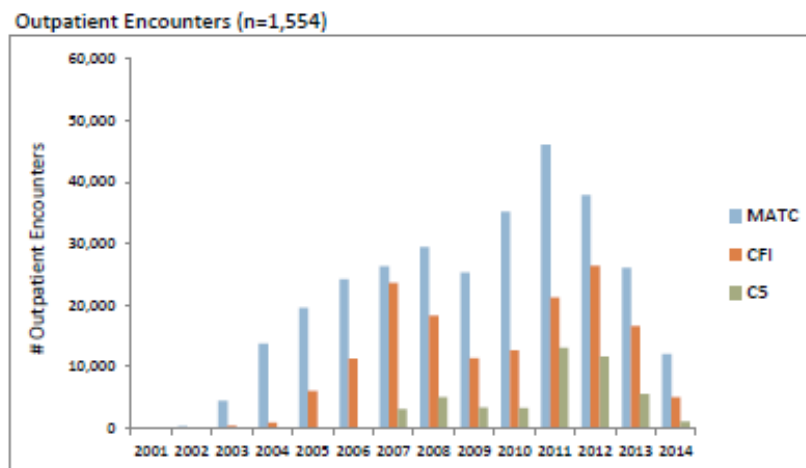
The number of active duty OEF/OIF/OND inpatient bed days and outpatient encounters seen at each of the ARCs over the course of the current conflicts are delineated in Figure 11, including the overlap of some patients who were seen at multiple ARCs. In interpreting these data it is important to note that MATC (and its predecessor, the Walter Reed Amputee Care Center) has been providing amputation care longer than the CFI and C5. San Antonio Military Medical Center and Navy Medical Cent San Diego, the predecessors of CFI and C5, were providing some amputee care for more than five years before their ARCs were opened in 2007.¹²⁰ Finally, “during the surge in Afghanistan (starting in 2010), [there was] a spike in the MATC patient numbers... These were very seriously ill multiple-limb amputees who required intensive care unit stays. Almost without exception, these patients were sent from Landstuhl Regional Medical Center in Germany to the closest CONUS Military Treatment Facility, which was Walter Reed.”¹²⁰



Figure 11. Active Duty OEF/OIF/OND Amputees (n=1,652) Inpatient and Outpatient Analysis¹²⁰



unique Px IDs	1,533	Beddays	Avg Beddays/Px
MATC	1,175	67,263	57
CFI	473	23,864	50
C5	170	2,992	18



unique Px IDs	1,554	Encs	Avg Encs/Px
MATC	1,192	300,781	252
CFI	566	154,049	272
C5	238	46,727	196

*Includes overlap of patients seen at multiple sites.

From EACE-R (amputee registry) for listing of patients, as of September 01, 2014. Excludes finger(s), thumb(s) and toe(s) amputations; includes partial foot and hand amputations.¹²⁰



C5's total number of encounters (including sports medicine) for calendar year 2013 was 165,484, with 125,877 of those in the physical therapy, occupation therapy, and chiropractic divisions.⁶⁷ C5 predicts a continued increase of two percent per year in demand for musculoskeletal services, with a continued decline in polytrauma rehabilitation, and expects that maintaining the current annual budget will be sufficient for sustainment in future years.⁶⁸

All three ARC patient loads have begun to drop steadily as the current conflicts wind down further.⁶⁸ This drop is dramatically exemplified at C5, where from its peak at more than 360 patients in January 2012, the patient load had dropped to just less than 120 in October 2013 and 55 as of February 2014. The latter number consists of 29 active duty personnel and 26 retirees and family members that includes 12 candidates for IDEOTM devices.⁶⁹

The ARCs have already begun to plan for accommodating the decrease in patient load while maintaining patient throughput levels to sustain provider skillsets. MATC has begun to include civilian amputees in research protocols. C5 is seeking to expand its geographic catchment area in order to maintain sufficient amputee patient load,⁶⁹ while the CFI is working to establish collaboration with the VA to share patient workload.

The Subcommittee attempted to assess the specific patient load required to maintain the clinical skills of amputee health care professionals, but there is a lack of specific data to support this objective. However, expert opinion indicated that each ARC would require between 50 and 100 new traumatic amputee patients per year to sustain the required clinical skillsets. Other experts indicated that a minimum of 30 patients would be required to maintain proficiency and sustain a clinical support team, but larger patient throughput would be desirable. These assumptions are based on an initial review of available information regarding patient costs and treatment metrics; but sufficient cost information is not available to conduct a true analysis or comparison among the ARCs.

It is evident that there will not be sufficient patient throughput from within DoD to sustain expertise at three amputee care centers during interwar years. Loss of provider training and maintenance of vital skills because of the decreased patient load may be ameliorated through the use of simulations, although they will not be sufficient to sustain all three ARCs during peace time. The effects of the decreased patient load may also be mitigated through national and international amputee care partnerships. A 1996 survey conducted by the Centers for Disease Control and Prevention (CDC) estimated that 185,000 individuals in the United States undergo amputations from all causes per year,¹²⁴ and it is possible that DoD could offer amputee services to the general population to increase patient load. DoD has already established some relevant relationships, such as the provision of care to six Georgian nationals (referred to in Section 2) and survivors of the Boston Marathon bombing in 2013. The Subcommittee visited the United States Army Institute of Surgical Research (USAISR) Burn Center to explore its model that provides care to civilian patients to sustain provider expertise during inter-war years. Although the model is not directly applicable to the sustainment of amputee care during peacetime, it does provide valuable lessons learned that may help to support the maintenance of amputee care skills.



U.S. ARMY INSTITUTE OF SURGICAL RESEARCH BURN CENTER

The USAISR Burn Center, as a DoD center of excellence in burn care, was established to provide care to civilian burn patients in addition to DoD beneficiaries, thereby providing sufficient patient load to sustain provider expertise during inter-war years. A memorandum dated 1964 initially established the transfer of indigent civilian patients from the Bexar County Hospital (R.B. Green) to the U.S. Army Surgical Research Unit at Brooke Army Medical Center.¹²⁵ Secretary of the Army designee status is granted to each civilian patient allowing him or her to receive care at the Burn Center. Additionally, in 1999, a memorandum of understanding established reimbursement by Bexar County Hospital District to Brooke Army Medical Center (BAMC) for treatment of trauma patients.¹²⁵

Similar to the ARCs, the USAISR Burn Center has used an interdisciplinary team approach to care, integrating researchers into the clinical setting, which has allowed for rapid translation of research into practice and resulted in significant advancements in the state of burn care. In light of lessons learned from the USAISR Burn Center, key considerations in the sustainment of an amputee care center include:

- Location, including housing availability, local airport support, and other logistical support;
- Partnerships with local nongovernmental organizations and local government;
- Availability of human resources, including the right combination of military, civilian, and contractor support to flex staffing to meet ebb and flow in demand, as well as attracting, training, sustaining, and retaining qualified staff and recognizing the importance of preventing burn out;
- Volunteer support to enhance capacity and services available at the center;
- Early establishment and maintenance of a patient database;
- Linking together of all IT systems;
- Determination of who the center belongs to, and issuance of a Joint Service policy prior to its establishment; and
- Access to non-DoD patients with Secretary designee status which would permit them to receive care at the center.

The majority of the USAISR Burn Center's patients during times of war and peace are civilian, and patients are received through referral via a national 1-800 number, referring physicians, or Emergency Medical Services directly off the street. The USAISR Burn Center operates on a mix of funding from a variety of sources that includes the U.S. Army Medical Research and Materiel Command for Research and Development, hospital billings, insurance, and uncompensated trauma funds from the state of Texas. However, the USAISR Burn Center is only collecting 20 percent of what it bills, making adoption of the model for amputee care challenging, especially in the current fiscal environment.

Finding 11: A critical mass of clinicians, technical specialists, and new trauma patients are needed to sustain amputee care skills. Expert opinion has universally concluded that DoD does not have adequate patient load during peacetime to sustain the clinical competency of its amputee care team.



Recommendation 11: DoD should build and strengthen national and international partnerships that allow for U.S. civilian or international amputees to receive care services in the ARCs, increasing the caseload of new traumatic amputees.

3.5 STRATEGIC CONSIDERATIONS

In light of the current fiscal environment, the drawdown of active combat personnel, a decreasing patient load, reduced resources, the continuing needs of the current amputee population, and the probability of future needs for traumatic amputation care, the Subcommittee examined various strategic considerations in determining its recommended approach.

As discussed above, DoD is engaging in national and internal collaborations to promote the uptake of state-of-the-art amputee care and prosthetics technology internal and external to DoD. These collaborations may prove vital in maintaining the necessary caseload to ensure sustainment of provider skills; however, the caseload will still be inadequate to support the current system of care. As such, the system of care must shift to accommodate the reduced number of patients.

Finding 12: There has been a significant decrease in the number of new traumatic amputees requiring care and available resources to sustain the care capability. To maintain the provider competencies and system capabilities in the interwar years, adequate caseload is necessary.

Recommendation 12: DoD should seek every conceivable opportunity by looking both within current models and outside existing ones to build the caseload necessary to sustain and advance state-of-the-art total amputee care, clinical competency, and expertise. If DoD exhausts every effort to build a caseload sufficient to sustain these current centers, then, and only then, should consideration be given to consolidation into a single center of excellence in order to sustain medical readiness in this critical component of casualty care.

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4. CARE OF THE AMPUTEE

Advanced Rehabilitation Centers (ARCs) are at the heart of the Department of Defense's (DoD's) approach to amputee care. The continuum of amputee care is rooted in the preservation of health and well-being of individual Service members and the units in which they serve. The foundation of amputee care begins with prevention. Once a Service member undergoes a limb preservation or becomes an amputee, care will be required for his or her lifespan. DoD is an international leader in advancing these required comprehensive and interprofessional health care and rehabilitation services for amputees. Key areas of amputee care are briefly discussed below, including prevention of amputations, trauma care and surgical considerations, pain management and other medical management issues, comorbidities, preventive medicine, and return to duty.

4.1 PREVENTION OF AMPUTATIONS

Prevention of amputations and the traumatic injuries that often result in amputations are a priority for DoD.¹⁵ The Department has dedicated significant resources and effort to preventing amputations. Improvements in personal protective gear, advances in medical practices, and implementation of safety education and training have all contributed to saving lives and limbs.^{15,126} Personal protective equipment, including the Improved Outer Tactical Vest, which accommodates Small Arms Protective Inserts, Enhanced Small Arms Protective Inserts, and Enhanced Side Ballistic Inserts, protect against torso and upper extremity injuries.¹²⁷ Additionally, the Department of Veterans Affairs (VA) Preservation-Amputation Care and Treatment program has significantly reduced nontraumatic amputations per year within the VA patient population.

4.2 TRAUMA CARE AND SURGICAL CONSIDERATIONS

General (Retired) Frederick Franks of the Defense Health Board and a combat amputee, stated, "amputee care for a combat amputee begins the moment you step on a land mine." Medical care begins the moment of the traumatic injury, which is often far forward in the battlefield. For those who experience traumatic injuries in combat that result in amputation, care begins at Level I, in the battlefield and at battalion aid stations. The Tactical Combat Casualty Care Guidelines^{128,129} provide evidence-based standards for care on the battlefield and are updated annually. For example, competent use of tourniquets early at the point of traumatic injury saves lives and limbs on the battlefield. Properly used tourniquets prevent major blood loss and are adjunct to stabilizing casualties immediately following traumatic injury.^{130,131} However, gaps remain in this far forward phase of care, including a lack of "effective treatment for intracavitary, noncompressible hemorrhage other than rapid transfer of the patient to a surgical facility."^{59(p1932-1932)}

Surgical care is commonly initiated when the patient reaches Level II care at a forward surgical facility. The Joint Trauma System Clinical Practice Guidelines guide providers at Level II facilities in carrying out the complex surgical interventions required to treat traumatic amputee patients.¹³² When patients arrive at a Level III Care Facility, a combat support hospital that provides the highest level of surgical care available within the combat zone, bleeding is definitively controlled and initial debridement of the injury is performed.⁵⁹ The Landstuhl Regional Medical Center in Landstuhl, Germany, the primary Level IV facility for the U.S.



military during the current conflicts, has been the first stop outside of the combat zone for many Wounded Warriors. Here, patients often undergo additional debridement of wounds to the extremities and further stabilization.⁵⁹

Reaching a Level V military medical center within the continental United States brings those with traumatic extremity injuries to a level of care where definitive surgery is performed, closing traumatic injuries, performing amputations, and undertaking recovery and rehabilitation.⁵⁹ The ARCs currently serve as the Level V facilities specifically for those with traumatic extremity injuries or otherwise requiring amputation.

The surgical strategy for extremity amputation has advanced during the current conflicts.¹³³ Previously, amputations were performed proximal to the injury to maximize healthy wound closure and a robust residual limb, which generally required only two surgeries.¹³³ Recent advances have prioritized maximizing residual limb length as increased limb length has been associated with improved quality-of-life outcomes, though it requires multiple surgeries over a prolonged period of time and a more complicated healing process with less “neat” healing.¹³³

Standardizing surgical approaches to amputation has been challenging, particularly for combat wounded with complex wounds.¹⁵ Most amputations require the expertise of multiple surgical subspecialties. It is critical that the medical and rehabilitation team—especially the prosthetist—and the patient are involved in decisions such as amputation versus limb salvage, and limb length if amputation is selected, prior to operation.¹⁵ However, “[e]very effort is made to preserve limb joints.”^{26(p5)} In addition to initial surgery, amputees have ongoing surgical needs throughout their lifespan. It is important for the orthopaedic surgeon to maintain regular communication with the patient and others on the provider team. Through strong communication networks, medical issues can be identified early and appropriately managed before developing into more complex problems. The medical team can determine when conditions can be addressed through alternatives to surgery (e.g., medical management for symptomatic neurotrauma and heterotopic ossification). However, if indicated, early surgical intervention may prevent severe, chronic, or detrimental conditions.²⁶

A particularly notable innovation in military trauma care has been the emergence of multidisciplinary trauma teams,¹³⁴ which have been shown to be effective in increasing communication and efficiency, thus improving patient outcomes.¹³⁴ For example, “military surgeons work collaboratively with various sub-specialists to perform innovative soft-tissue, bone, nerve, muscle, and vascular grafts to preserve as much of the limb as possible.”¹² Rehabilitation experts, prosthetists, patients, and family members are all involved in surgical decisions to maximize benefit and align surgical care with other aspects of treatment and life.¹²

4.3 REHABILITATION

The rehabilitation process for traumatic amputees is complex, highly individualized, and widely varied in length of time. Rehabilitation should be initiated early, as soon possible after amputation. Physical therapy, occupational therapy, prosthetics and orthotics, peer support, sports and recreational activities, and community reintegration are all core aspects of the rehabilitation process. This process is composed of four-phases that include: (1) initial



management, (2) preprosthetic, (3) prosthetic/ambulation, and (4) progressive activities/return to active duty.¹³⁵

The Subcommittee learned from briefings from the ARCs that physical therapy has a central role in assuring that an amputee achieves the maximum possible level of functional ability, allowing the amputee to meet his or her occupational and recreational goals. The amputee must be taught about residual limb care before being fitted with a prosthesis. The physical therapist plays an important role in training the amputee in prosthetics use, including teaching him or her how to use and care for the prosthesis, preparing the amputee for prosthetic gait training, and re-learning the efficient and safe motions of gait and balance. Finally, the physical therapist trains the amputee to engage in higher levels of movement beyond walking, possibly including sports and recreational activities.

During the acute inpatient stay when surgical management takes place, the protective healing phase occurs. This is the first phase of rehabilitation. Rehabilitation providers work at this stage to promote early functional skills, initiate early conditioning activities, and educate the patient and his or her family about the recovery process and other issues related to living with an amputation. Functional activities include bed mobility, transfers, and wheelchair management. Such activities are taught to the patient as early as possible, along with a focus on flexibility to prevent decreased range of motion and contracture. Strengthening of residual limbs and trunk core stabilizers are important aids to recovery, ambulation, and reduction of back pain. Thus, strengthening exercises are initiated as soon as they are tolerated. Aerobic training to increase cardiovascular endurance and balance practice are other crucial rehabilitative components that should be initiated prior to ambulation with assistive devices.

The goal of occupational therapy is to return an amputee to his or her highest potential for performance of daily occupational activities that lead to a meaningful and satisfying life. These include work, leisure, and self-care-related activities.¹³⁶ The majority of occupational activities are performed with the hands; thus, the role of the occupational therapist focuses heavily on helping upper limb amputees perform these tasks with and without prostheses.¹³⁶ Occupational therapy is heavily involved in training the amputee to use prosthetics and conduct activities of both daily living and occupation-specific activities, including those unique to active duty, such as weapons training, as well as recreational sports activities. Peer support is an integral aspect of rehabilitation, providing amputees with motivation and inspiration to continue expanding their limits and moving forward. Similarly, grouping patients with like injuries together during rehabilitation can increase their self-efficacy, although it is unclear to what extent.¹³⁷ In these groups, Wounded Warriors are able to see others further along in their course of recovery and rehabilitation.¹³⁷ Peer-to-peer counseling that occurs between Service members who have suffered severe major limb trauma can also provide motivation to continue treatment and rehabilitation.¹³⁷

The daily living apartment is a realistic apartment that is not adjusted to be compliant with the American Disabilities Act or otherwise accommodating to the amputee and provides a realistic environment for amputees to practice activities of daily living and self-care, such as cooking, doing laundry, and bathing.^{64(p4-3)}



DoD ARCs have partnered with the VA and the Amputee Coalition to implement peer support programs with volunteer amputees, ideally with military experience, trained to support traumatic amputees.¹⁵ The peer amputees provide emotional support to the new amputees as well as feed information back to providers regarding how the new amputee is progressing.¹⁵

Sports and recreation is an important motivational factor in DoD amputee rehabilitation and recovery.¹³⁸ Physical activity has been demonstrated to aid the rehabilitative process and provide therapeutic benefits.¹³⁹⁻¹⁴¹ It also helps decrease self-reported stress, pain, and depression, as well as improve quality of life and body image among people with disabilities and amputations.^{142,143} Advances in assistive technology have dramatically increased the opportunities for amputees to participate in sports and recreational activities.¹³⁹ These devices include not only activity-specific lower and upper limb prostheses, orthoses, and exoskeletons, but also wheelchairs and other devices.¹³⁹

EQUIPMENT AND TECHNOLOGY

Specialized equipment and technology are instrumental in the care and rehabilitation of traumatic amputees. Primary components include a Gait Laboratory (Gait Lab), Computer Assisted Rehabilitation Environment an activities of daily living apartment, in-house prosthetics laboratory, and innovative prosthetic technology.⁶⁴

Amputee gait assessment is performed with the goal of identifying gait parameters that differ from the gait of able-bodied individuals, to inform the development of corrective strategies that enhance efficiency, comfort, and aesthetics of amputee gait.¹⁴⁴ The Gait Lab uses “advanced high-speed digital video technology, force measures and advanced kinematic techniques to analyze” the amputee’s gait.^{64(p1-1)} The Gait Lab is used in both a clinical and research capacity.⁶⁴ The lab collects data on an amputee patient’s gait and the data are analyzed to inform research, as well as to provide feedback to providers, prosthetists, and patients, to inform treatment and rehabilitation plans and prosthetic adjustments.⁶⁴ On the research side, the Gait Lab is used to examine novel prosthetic components, therapeutic practices, and surgical techniques associated with the rehabilitation of traumatic amputees.⁶⁴

The CAREN “is a six-degree-of-freedom motion platform which contain[s] an instrumented dual-belt treadmill with two six-degree of freedom force platforms that synchronizes in real time with a virtual environment projected onto a 120-degree curved screen. A 12-camera motion capture system tracks the movement of retro-reflective markers worn by the participant, and allows interaction with the virtual scene.”^{64(p4-4)}

Prosthetics, exoskeletons, and orthoses are provided to patients with amputation and/or major extremity injury with the goal of allowing the Wounded Warrior to achieve basic function or ambulation, progress to a variety of advanced activities, and, when desired, perform tasks required for return to duty.¹⁴⁵ The ARCs employ innovative prosthetic, exoskeletal, and orthosis technology as a core aspect of care. With prosthetists on site with the provider team and the patient at each ARC, patients and their health care providers can develop innovative approaches to address discomfort and dysfunction. This unique care model allows for challenges to be quickly identified during rehabilitation and the prosthetic adjusted through an iterative approach



that enhances rather than hinders the rehabilitation process and prosthetic utilization. This also creates an environment where experimentation fostered by patient-provider-prosthetist communication enables rapid advancement and application in practice. One example of this, shared with the Subcommittee by an amputee with a hemipelvectomy, was when he continued to work with his providers to make the prosthetic fit more comfortably, leading to experimentation with a breast implant as a cushion between the skin and the prosthetic, which resulted in significantly increased comfort and decreased skin disruption. Advances in prosthetics technology were often developed as solutions to address complex and unique needs of individual patients and later became more widely available commercially, thus improving options and care for veterans and civilian amputees and advancing the broader field.⁶⁴ As a result, many of the leading technologies used today can be attributed to the pioneering work of the clinical teams at the ARCs.⁶⁴

The in-house prosthetics laboratory at the ARC enables patients to receive prostheses or revisions to their prostheses within one or two days. This turnaround is significantly faster than the weeks-long wait for the development and adjustment process when the prosthesis is manufactured and modified off-site and qualitatively results in better fit and quality of life for the amputee. The ARCs also are the first DoD facilities to provide new cutting-edge prosthetic advancements, such as microprocessor prosthetic knees (C-Legs), which rapidly assess and adapt to environmental input to best support the amputee's activity, whether walking, running, climbing stairs, or otherwise.¹⁴⁵ They also foster continual advancement of prosthetic technologies.^{64(p1-1)}

Three-dimensional prototype production modeling the limb's soft tissue and bone is now possible at Walter Reed National Military Medical Center (WRNMMC) using a computed tomography scanner, which can be used to improve the fit of a prosthesis. This makes long-distance prosthetic maintenance, repair, and replacement possible globally for the first time ever. A traumatic amputee "can be scanned at one location, the digital data sent electronically to WRNMMC, and the three-dimensional model prepared that day."⁶⁴ As such, prostheses can be modified or replaced without requiring the amputee or the provider to travel. The completed components can be sent out the next day, and providers where the Service member is stationed can use telemedicine technology to link with the WRNMMC providers to make any final adjustments.^{64(p4-3)}

In addition to prostheses, orthoses, and exoskeletons, other assistive devices are often essential to aid amputees in carrying out activities of daily living as independently as possible. Such devices include a variety of adaptive wheelchairs, adaptive driving controls including steering devices and accelerators, vehicle access technology such as automatic car door openers, a power-based seat to aid transfer in and out of the vehicle, and robotic aids.¹⁴⁶ The amputee will likely use multiple assistive devices, and the types of devices used will likely change over the course of his or her lifetime.¹⁴⁶ It is critical that prostheses and all other assistive devices be carefully selected to best fit the individual's needs and activities and that the amputee is trained to effectively use the device.¹⁴⁶



4.4 MEDICAL MANAGEMENT

Management of infections in the traumatic amputee has advanced dramatically in recent years. However, infections remain a significant challenge because of the complex wounds, staged treatment in multiple treatment facilities, and prolonged healing processes that commonly include ongoing irritation from prostheses and orthoses. Surgical site and implant infections are frequently associated with surgery, and related standards of care are discussed in the *Textbooks of Military Medicine Care of the Combat Amputee*.¹⁴⁷ Debridement of infected or devitalized tissues and removal of implanted hardware are the primary treatment of infections to the soft tissue or implanted hardware, with use of antibiotics playing a secondary role.⁶ Patients with extremity trauma or amputations often undergo multiple wound debridements before the wound is definitively closed. Multidrug-resistant organisms (MDROs) continue to be an infection concern for amputees, as they pose an international dilemma across all aspects of medicine. Successful MDRO control measures that have been established in the medical community must be followed among amputee care providers.

Wound care is frequently complex among traumatic amputees because of the multiple complex injuries experienced by a single patient. A thorough understanding of wound care and its phases (hemostasis, inflammation, proliferation, and remodeling) is important to provide quality care and overcoming accepted but outdated common standards. Important considerations in wound treatment include maintaining tissue viability through judicious debridement techniques and restoring moisture balance that is necessary for healing.⁶

Weight-bearing progression is another critical consideration in medical management of the traumatic amputee. The right balance must be achieved to allow adequate healing and early weight bearing to minimize the negative effects of prolonged inactivity. Prolonged bed rest and inactivity have been demonstrated to have significantly negative physical and psychological consequences.⁶ However, the complex wounds commonly associated with traumatic lower limb amputees often include femoral or pelvic fractures, which require adequate time protected from significant force or pressure in order to heal.

Pain management is a core component of any inpatient or outpatient amputee care program.¹⁵ Point of injury and acute care pain as well as chronic pain are areas of concern among traumatic amputees¹⁴⁸ and will therefore be an ongoing need for the current cohort of combat amputees. Pain significantly affects an amputee's participation in rehabilitation therapy and prosthetic use, negatively affecting healing and return to full functioning. Pain also significantly alters quality of life over the long term, including participation in social activities and likelihood of employment.^{15,149,150} One study found that the majority of upper limb amputees experience multiple types of pain (including phantom limb pain, residual limb pain, back pain, neck pain, and non-amputated-limb pain), with only 10 percent reporting no amputation-related pain.¹⁵⁰

Pain management standards established by the World Health Organization, The Joint Commission, and the Accreditation Council for Graduate Medical Education provide guidance to organizations and providers. However the complexity of pain needs for traumatic amputees, and especially multiple amputees, is challenging to manage and requires active monitoring and treatment optimization by all providers on the multidisciplinary care team. Frequent communication between the patient and providers, aggressive preoperative and perioperative



pain management, and use of multi-modal medications^{15,26} with a highly individualized pain management plan is essential.¹⁴⁸ The multi-modal approach “can help decrease the required dosage of a single medication, thereby minimizing the risk of side effects associated with dose escalation,”^{26(p51)} and, importantly, minimize the risk of developing tolerance, dependence, and addiction to opioid medication.²⁶

At WRNMMC, amputees are often issued a patient-controlled anesthesia pump during the perioperative period and then are quickly converted to long-acting opioids after definitive surgery. Short-acting opioids also are used for breakthrough pain or premedication prior to therapy.^{15(p13)} Further specifics regarding pain management practices are described by Pasquina and colleagues.¹⁵ Pasquina et al. note that the regional anesthesia team and the use of “peripheral infusion catheters...has had a dramatic effect on pain control, reduction in medication use, and participation in therapy.”^{15(p13)} Complementary, integrative, and alternative pain management measures also are recommended, with careful attention to indications and contraindications.¹⁵ “It is also generally accepted that the use of an appropriately fitted prosthetic socket reduces pain.”^{15(p13)}

Residual limb pain and phantom limb pain are reported at rates of 55 percent and 85 percent of amputees, respectively.¹⁵ Residual limb pain and phantom limb pain can occur separately or in tandem, and their complexities are generally not understood, leading to challenges in treatment, mistakes, or under-reporting of the condition.¹⁴⁸ Phantom limb pain is usually brief, lasting days or weeks. However such pain can become chronic and has been found to last as long as 25 years in some amputees.¹⁵¹ Residual limb pain is common early in postoperative care and rehabilitation and diminishes relatively quickly, with a low prevalence after two years.¹⁵¹ A British publication proposes a multidisciplinary treatment approach to traumatic amputee phantom limb pain “which acknowledges the interplay among central, peripheral and psychological factors against a background of individual experiences and concern.”^{152(p6)} The goal of the approach is to prevent cortical reorganization and normalize visual, sensory, and motor input to the central nervous system.¹⁵²

One promising therapy for phantom limb pain which has been effective for many amputees is “mirror therapy.” In this therapy, amputees view the reflected image of the intact limb moving in a mirror while simultaneously moving their amputated, or “phantom” limb and 60% of patients in a small case series reported relief of phantom limb pain.¹⁵³ A randomized, sham-controlled study of mirror therapy was conducted at the former Walter Reed Army Medical Center and found to be highly positive for mirror therapy relieving phantom limb pain.¹⁵⁴ On the basis of these published findings, mirror therapy is offered to patients at all ARCs and has been adopted by civilian medical centers both in the US and overseas. Another therapy based upon the principle of visual feedback (as seen in mirror therapy) uses a virtual reality-generated avatar upper limb to treat upper limb phantom limb pain.¹⁵⁵

In early 2014, a small-cohort, retrospective study found unintended positive effects on post-amputation neuroma pain from targeted muscle re-innervation, a “procedure designed to permit intuitive control of upper-limb prostheses through a set of novel nerve transfers by providing both a distal target and a vascularized scaffold on which to guide sprouting nerve axons,” which restores continuity to the peripheral nervous system.^{149(p2)} Neuroma pain is caused when the



severed or damaged ends of peripheral nerves form neuromas because of abnormal regrowth.^{148,149} This pain is a common cause of residual limb pain and is particularly problematic among traumatic amputees because of the extent of nerve injury, the number of nerves injured, and the superficial location of these nerves in the residual limb.”^{149(p2)} Neuroma pain is difficult to treat medically or surgically, and there is a lack of consensus on the most effective treatment.¹⁴⁹ This finding aligns with DoD’s prioritization of the identification of effective treatment for neuroma pain for amputees¹⁵⁶ soon after a 25-year outcomes study was published in 2013. The study concluded that treatment of neuromas in the upper extremity remains a difficult problem with no single recommended approach and suggested that nerve repair interventions are more effective than those that excise or bury the damaged nerve.¹⁵⁷

Many different therapies to treat residual limb pain have been tried with little success, and a lack of consensus remains regarding which treatment modalities are more effective, though a multi-modal approach is generally agreed to be the most effective.¹⁵¹ Many amputees use self-treatment methods to manage their pain in addition to the surgical, medical, and complementary medicine treatments available, although the effectiveness of these self-treatments has not been determined.¹⁵⁸ Examples of self-treatment methods include “residual limb tapping, massage, towel pulls, desensitization, distraction, meditation, and alcohol/drug use.”^{158(p55)}

4.5 COMORBIDITIES

Traumatic amputation is associated with a high risk of multiple comorbidities and secondary complications,¹⁵ including a significant incidence of diabetes, obesity, hypertension, and cardiovascular disease which can diminish both length and quality of life for amputees. Some of the most common comorbidities and secondary complications among traumatic amputees include heterotopic ossification, peripheral nerve injuries, psychological challenges, and traumatic brain injury (TBI). Heterotopic ossification, the abnormal formation of bone in soft tissues, has been documented to occur at high rates among traumatic amputees of the recent conflicts.

Although much has been learned in the past decade about the occurrence of heterotopic ossification and its treatment, further research on prevention and more effective treatment is needed.⁶ Additionally, although not always apparent at the time of initial trauma, peripheral nerve injuries are common among traumatic amputees and have significant effects, including numbness, pain, parenthesis, and weakness. It is important to conduct regular neurologic examinations to identify such injuries.⁶ Polytrauma patients who experience amputation frequently suffer severe burns as well, which can create challenges in maintaining range of motion and socket interface, thus interfering with recovery and rehabilitation activities.^{127,159} Rarely addressed in discussion and with scant scientific literature in regard to treatment¹²³ are the traumatic genital injuries often also sustained by the Department’s traumatic amputees, which can have devastating and deeply personal psychological and physiological lifelong impacts on Wounded Warriors and their families.¹²²

Psychological support for traumatic amputees is paramount to aid in overcoming the myriad related mental health issues they may face in addition to their physical injuries. Common psychological issues encountered among traumatic amputees include fear of failure or rejection, loss of military careers, future under-employment, as well as post-traumatic stress disorder (PTSD), severely altered body image, and low self-esteem. Psychological health practitioners



state that the loss of a body part is similar to the loss of a loved one and may be associated with a prolonged grieving process.¹⁶⁰ Wain and colleagues¹⁶⁰ note that the primary focus of psychological interventions should be on encouraging sleep, controlling pain, and alleviating anxiety symptoms. Involvement of psychological health professionals on the care team is critical to address these issues early and comprehensively. Deeply embedding psychological care within the care process is vital in overcoming Service members' reluctance to seek treatment because of fear of stigmatization.¹⁶⁰ Additionally, hope and determination have been identified by providers and patients alike as important motivators for recovery, and must be encouraged.

TBIs are another common problem, occurring in approximately one-third of combat casualties, particularly among polytrauma patients who are primarily amputees as well.¹⁶⁰ Thus, many traumatic amputees also have TBI, which can interfere with and complicate the rehabilitation and recovery process because of significant cognitive, memory, awareness, behavioral, and emotional challenges. Because of these significant challenges and needs, those with severe TBI are commonly transferred to VA polytrauma centers equipped to treat such patients until the Wounded Warrior has recovered to a point that he or she can be transferred to an ARC for amputation-specific care.¹⁶⁰

Among polytrauma patients wounded by blasts (often amputees), hearing and balance deficits are quite common, though often initially overlooked.¹⁶¹ Hearing loss can be problematic among amputees as it can hinder communication, further complicating rehabilitation efforts. In addition, vestibular problems causing balance deficits may be misdiagnosed in lower-limb amputees by mistakenly attributing balance impairment to the limb loss.¹⁶¹ Therefore, it is particularly important to conduct comprehensive evaluations of the auditory system in amputees.¹⁶¹

4.6 HEALTHY BEHAVIORS AND PREVENTIVE MEDICINE

DoD is committed to the lifelong well-being of its Service members. Preventive medicine is critical, as studies have demonstrated that the long-term effects of living with an amputation lead to negative health outcomes that are significantly more serious than those of non-amputees.⁶ These studies are facilitated by creation and maintenance of long-term amputee patient registries that track health outcomes through amputees' lifetimes, allowing providers and researchers to better predict chronic disease risks for this unique population. It is important to address primary health concerns early to prevent, minimize, and slow the development of associated secondary and tertiary health concerns later in life.¹¹⁸ Many sequelae are understood and well documented in the scientific literature. The most common known premature mortality and morbidity risks are related to nutrition, physical activity, excess weight, tobacco and substance use, stress, and relationships and community ties. Additionally, a significant gap remains in understanding the long-term health outcomes and needs of this population.

The most prominent and problematic morbidity and mortality risks associated with living with an amputation include musculoskeletal, cardiovascular, metabolic, and endocrine issues as well as obesity. Further, extremity injuries and amputation have been documented to be among the most important factors associated with long-term outcomes and permanent disability.¹⁶² Studies have demonstrated that in the long term, amputees face higher incidence of osteoarthritis,



chronic and significant back pain, and a higher rate of bone density loss in the remaining stump as well as in bones throughout the body. Cardiovascular and metabolic issues are significantly worse among aging amputees than non-amputees, and appear to be directly related to traumatic amputation. Hypertension, ischemic heart disease, and diabetes mellitus have all been documented at higher rates among traumatic amputees, and traumatic amputees are 65 percent more likely to die of coronary and peripheral vascular diseases than non-amputees.⁶ Traumatic amputees can also experience endocrine problems resulting from polytrauma. Because of the nature of the complex injuries experienced through trauma, all organ systems can be affected. Chronic endocrine deficiencies, most notably hypogonadism, as well as impaired sexual function and fertility challenges have been documented among Wounded Warriors, but have received limited attention in the literature.⁶

The myriad morbidity and mortality risks highlight the importance of healthy behaviors, and a proactive focus in amputee care on comprehensive nutritional, exercise, and wellness counseling and support. However, the metabolic costs of walking are much higher for amputees than non-amputees, making it hard for amputees to remain active.⁶

A 2010 study reported findings from a 2007-2008 survey comparing health status, prosthetic-device use, and long-term prognosis between 73 Vietnam veterans and 61 Operation ENDURING FREEDOM (OEF)/Operation IRAQI FREEDOM (OIF) Service members^h with multiple traumatic limb loss.¹³ Chronic back pain (19 percent and 21 percent) and phantom limb pain (69.9 percent and 68.9 percent) were concerns at similar rates between the two groups, while residual limb pain was lower among Vietnam (46.6 percent) than OEF/OIF (68.9 percent) veterans.¹³ Depression, PTSD, mental health, and pain scores were not significantly different between Vietnam and OEF/OIF veterans.¹³ Understandably, several age-related comorbidities were reported more frequently by the Vietnam group than the OEF/OIF group, including arthritis (52 percent versus 15 percent), heart attacks (16.4 percent versus 0 percent), diabetes (15.1 percent versus 0 percent), and kidney disease (6.8 percent versus 0 percent).¹³ The OEF/OIF group received a prosthetic device at approximately 15 times the rate of the Vietnam group, used at least one prosthetic device at a higher rate than the Vietnam group (92 percent and 68 percent, respectively), and had higher satisfaction with their care (7.9 versus 6.7 on a scale of 0 to 10).¹³

The focus of the ARCs is to provide amputation care, including acute trauma care, surgery, and rehabilitation. As such, the ARCs have not placed a high priority on initiation and maintenance of healthy behaviors related to overall mortality risk. The extent to which the ARCs have made a concerted effort with regard to healthy behaviors is from the intent to facilitate a full and speedy recovery to attain maximum ability, rather than an intended preventive care approach. While there is a lack of preventive medicine programming at the ARCs, the ARCs provide an ideal environment for such a focus as they are small, closed systems of care with a small and

^h Significant demographic differences between the two populations are important to note, including: age (60.7 years among Vietnam group versus 28.0 years for the OEF/OIF group); gender (all in the Vietnam group were male versus 95 percent in the OEF/OIF group); marital status (76 percent in the Vietnam group were married and 85 percent had children, versus 61 percent of the OEF/OIF group were married and 46 percent had children); active duty status (none of the Vietnam group were on active duty, versus 23 percent of the OEF/OIF group, and 14.8 percent were still in rehabilitation); employment (76 percent of the Vietnam group was employed versus 53 percent of the OEF/OIF group with an additional 15 percent in school).¹³



concentrated patient population having similar backgrounds and needs. A better understanding of the long-term outcomes and needs of this population could inform more appropriate, targeted, and robust prevention programming.¹⁶²

Finding 13: The ARCs lack robust clinical and research programs designed to enhance the long-term health of the amputee population, reduce the risk of premature mortality, and manage comorbidities associated with amputations.

Recommendation 13: The ARCs should develop, pilot, and evaluate prevention and wellness programs to better manage comorbidities and reduce the risk of long-term chronic disease for amputees.

OUTCOMES

The main goal of amputee care, as with treatment of any injured individual, is to return the individual to independence and productive functioning in daily life.⁵¹ Return-to-work is often used as a surrogate measure of functional outcome after traumatic injury^{51,163} and has often been studied in reference to the amputee population.^{51,164-166} Return-to-work rates for civilian lower extremity trauma patients has been documented at 49 to 53 percent.¹⁶⁷ In the military, return to duty is often considered a parallel metric to return to work. However because of the intense physical and psychological requirements one must meet to return to duty, it would be expected that return-to-duty rates would be far lower than return-to-work rates in the civilian sector.

Several studies have examined return to duty among traumatic amputees and found that return to duty is unlikely, as the job requirements are intense.^{41,137,163,168,169} Indeed, return to duty rates are around 27 percent.¹⁷⁰ The number of amputees returning to their pre-injury military occupation specialty (MOS) (indicating a return to the same or similar duties) is even lower, at two percent.^{41,51} MOSs vary greatly in the spectrum of roles and associated duties, requiring varying levels of physical and psychological ability and agility.^{41,51}

“Each branch of the DoD has specific standards by which it determines whether or not an injured or ill member will be continued on active duty, based upon the severity of the condition and the imposed functional limitations.”^{171(p55)} The Medical Evaluation Board determines retention on active duty, and the Physical Evaluation Board (PEB) within each military Service determines fitness, meaning the Wounded Warrior’s ability to continue service on active duty.^{51,171} The PEB can grant disposition for a Service member to be permanently retired, separated with severance pay, placed on the temporary disability retirement list, fit for duty, or continued on active duty (COAD).⁵¹

Amputees have intermittently returned to duty throughout military history, including the Invalid Corps during the Civil War and World War II veterans recalled to duty to support the Korean War.¹⁷¹ In the recent OEF/OIF/OND conflicts, the percentage of amputees returning to duty is higher than any time in history because of a strong culture of acceptance and opportunity for amputees within the military; however, the numbers remain low. While most amputees did not return to active duty, of the 1,937 Active Duty Service Members who sustained an amputation (conflict and non-conflict), 528 elected to remain in an active duty status and 71 deployed to the combat theater after having sustained an amputation.¹⁷⁰ In a study of combat amputees between



September 2001 and July 2011, Krueger and Wenke found that the majority of significant predictors of whether or not a combat amputee would deploy again are related to individual and social factors and not treatment.⁵¹ Their findings indicate no significant difference in deployment of amputees among the branches of Service. Primary predictors of deploying after sustaining a combat-related amputation were:

- level of amputation, with Wounded Warriors with transtibial amputations being more likely than other amputees to return to active duty;
- age and rank, with those of senior rank or age being more likely than other amputees to return to active duty;
- PEB disposition, with those having a disposition of being fit or COAD being more likely than other amputees to return to active duty; and
- being a member of the Special Forces.⁵¹

Several of these findings are reflected in other return-to-duty studies,^{41,163,168} with rates among amputees in the Special Forces at 21 percent fit-for-duty and 58 percent retention in military service, as reported by Belisle et al.⁴¹

Early studies have found that among limb salvage patients using the Intrepid Dynamic Exoskeletal Orthosis (IDEO)TM and receiving care through the *Return-to-Run* clinical pathway, return-to-duty rates for limb salvage patients have increased, bringing limb salvage return-to-duty rates above those of amputees, at 19-20 and 12.5 percent respectively in a cohort of 115 Wounded Warriors with open tibia fractures.^{163,169} It is important to note however, that studies to date have only included small sample sizes and are relatively recent; therefore, they do not yet reflect longer-term outcomes.^{163,169}

All of these factors converge, presenting a unique amputee population with needs that require enhanced attention and validate transformation of DoD's model of care for amputees. To meet the needs of this extraordinary patient population, DoD has redefined amputee care and rehabilitation, enabling wounded Service members to attain levels of functioning previously thought impossible, and in many cases allowing amputees to set increasingly high goals, including returning to active duty. Limb salvage, the IDEOTM, and other related technologies and advancements are providing potential amputees with viable alternatives to amputation. Furthermore, the evolution of care in DoD has broadened the scope of what is considered to be within the field of amputee care. Such advancements and technologies are considered in this report in Sections 3 and 4.

Finding 14: DoD has established a process and infrastructure specifically aimed at supporting amputees to return to active duty which is vital to DoD's future operational readiness in addition to improving the quality of life for those who have sustained traumatic limb injuries.

Recommendation 14: DoD should continue to advance the progress that allows amputees to return to active duty.



4.7 CASE MANAGEMENT

Social workers and nurse case managers coordinate continued care and facilitate communication among the patient, family, and various providers.¹⁵ At the ARCs, “integrated medical and non-medical case management have been integral to coordinating care, transitions from DoD to VA and for family support.”^{69(p6)} Integrated and comprehensive case management is implemented throughout the patient care process at the ARCs; however, that case management does not formally begin until the patient reaches an ARC and ends on discharge from the ARC.

Amputee care is lifelong, not episodic, care. Once amputees get through the acute care phase, surgery, and rehabilitation, they live as amputees with ongoing prosthetic needs, prosthetic fittings, and treatment of comorbidities. DoD is committed to providing lifelong care to amputees to supplement VA services.¹⁵ However, this care remains a challenge, as long-term needs are not yet fully understood, and DoD will need to rely on partnerships with the VA as well as with other public and private institutions to maintain the appropriate level of care.

Unfortunately, once the amputee transitions out of a DoD ARC, ongoing care becomes more difficult, as the geographic distance from their duty station, home, and DoD or VA health care facilities is often significant.¹⁵ In these circumstances, ongoing coordination of continued care is challenging, and both standards and availability of care vary in the private and public sectors across the country.¹⁵

MILITARY MEDICAL DISABILITY SYSTEM AND INTERFACE WITH THE DEPARTMENT OF VETERANS AFFAIRS

Not only is the transition from DoD to VA difficult for amputees and their family members (as it is for other Wounded Warriors), the military medical disability system is also difficult to navigate.¹⁵

Important elements of the DoD ARCs are the PEB liaison who ensures the amputee’s understanding of his or her PEB evaluations, and the VA counselor who ensures that amputees are aware of their options in the VA system prior to leaving DoD.¹⁵

DoD and the VA offer multiple support systems and programs for Wounded Warriors, including traumatic amputees. Examples of these programs are listed in Figure 12.¹⁷²

While it is beyond the scope of this report to describe all aspects of amputee care and related best practices, this section provides an overview of amputee care from point of injury through long-term care, highlighting key areas of significance. Because of the rapidly evolving nature and complexity of the field,

Figure 12. Examples of DoD and Other Support Programs for Wounded Warriors, Including Amputees¹⁷²

Military Programs:

- Army Wounded Warrior Program
- Marine Wounded Warrior Regiment
- Navy Safe Harbor
- Air Force Wounded Warrior Program
- Military Severely Injured Center
- Operation Warfighter Program
- Defense Department Computer and Electronic Accommodation Program
- Labor Department Recovery and Employment Assistance Lifelines
- Life Insurance, Special Pay Programs, and Travel Benefits
- Heroes to Hometowns
- Military Support Systems services

Veterans Services Organizations:

- Paralyzed Veterans of America
- Disabled American Veterans
- Wounded Warrior Project

Adapted from Sporer, et al. 2009.



the material provided in this section is in no way intended to be comprehensive. More comprehensive and current information is available from the following resources:

- **The DOD-VA Extremity Trauma and Amputation Center of Excellence (EACE).**¹⁷³ EACE's mission, as mandated by Congress, is to "serve as the joint DoD and VA lead element focused on the mitigation, treatment and rehabilitation of traumatic extremity injuries and amputations,"¹⁷³ and to "implement a comprehensive plan and strategy, to conduct clinically relevant research, foster collaboration and build partnerships across the multidisciplinary international, federal and academic networks to optimize the quality of life of service members and veterans."¹⁷³ As such, EACE provides a valuable resource at a single location, with awareness of the most current evidence and best practices in the continuously evolving field of amputee care.
- **The 2009 publication of *Care of the Combat Amputee in the Textbooks of Military Medicine* series by the Borden Institute.**¹⁴⁷ This textbook was written by leaders in areas related to the care of the combat amputee and covers the spectrum of issues pertaining to such care. Chapters cover topics such as the VA system of care for the polytrauma patient, vocational rehabilitation, military and veteran support systems, surgical considerations, medical issues, pain management, psychiatric intervention, traumatic brain injury, and prosthetics. There is currently discussion among the DoD amputee care community of possibly publishing an update to the textbook as the field has advanced dramatically over the past decade.
- **The 2013 VA/DoD Clinical Practice Guideline for Management of Upper Extremity Amputee Rehabilitation and the 2007 VA/DoD Clinical Practice Guideline for Rehabilitation of Lower Limb Amputation.**^{174,175} These documents were created by interagency work groups of experts in amputee care, and are based on the best available evidence at the time. The guidelines provide recommendations for practice and review the evidence available at the time of publication for peri/post-operative, pre-prosthetic training, prosthetic training, and long-term/follow-up phases of care.

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5. DATA, SURVEILLANCE, AND RESEARCH TRANSLATION

5.1 DATA AND SURVEILLANCE

Public health surveillance can be defined as “the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.”¹⁷⁶ To be effective, a medical care system must have accessible information on its patient population.¹⁵ Department of Defense (DoD) Directive 6490.02E states that “comprehensive health surveillance is an important element of force health protection programs to promote, protect, and restore the physical and mental health of DoD personnel throughout their military service and employment, both in garrison and during deployment.”¹⁷⁷ As an institutionalized component of its health care system, DoD should have a database to track its amputee patient population using standardized data elements across DoD from point of injury through treatment, rehabilitation, and lifelong quality of life outcomes. Analysis of such data provides critical information to the clinical care team,¹⁵ technology and assistive equipment developers, and DoD leadership for use in decision making and policy formulation.

One important source of such critical data is a registry. Registries can be used to conduct research, in addition to being used to estimate the extent of a condition or disease within a population, and to determine incidence of disease and trends.¹⁷⁸ A registry may be used to collect, store, retrieve, analyze, and disseminate information on individuals. These individuals have either a particular disease, predisposition to a given health condition, or exposure to conditions or substances that have been linked to negative health events.¹⁷⁹ The Assistant Secretary of Defense for Health Affairs’ Memorandum, “Guidance for the Management of Registries in the Military Health System (MHS),”¹⁷⁸ provides guidance that DoD registries shall employ reusable interfaces and data services, and use protocols and methods approved by the MHS Chief Information Officer to access authoritative data sources.⁹⁶ It is important to note that the data are only as good as the administrative data collection processes in place at the facility level. DoD and the Department of Veterans Affairs (VA) have several registries that track amputation-related information as discussed below. Some are specific to amputation data, while others are more general and include amputation data as part of a broader data set. However, these registries are neither centralized nor integrated, and data are not acquired in a consistent manner.

EXPEDITIONARY MEDICAL ENCOUNTER DATABASE

The Naval Health Research Center’s (NHRC’s) Tri-Service Expeditionary Medical Encounter Database (EMED) is DoD’s largest and most comprehensive database of all casualties occurring in overseas contingency operations (OCOs), beginning in October 2001, and as such, includes all OCO amputees, including delayed amputations and limb salvage cases.¹⁸⁰ It is the only database that integrates medical, tactical, intelligence, personnel, and deployment data as it tracks individuals longitudinally. Data in EMED are of research quality, as all data are analyzed, verified, and validated by NHRC staff, rather than being pulled directly from the MHS. Data in EMED include class of casualty (e.g., battle injury, illness/disease), tactical characteristics associated with casualty (e.g., mounted or dismounted, strike point), injury, and treatment received during evacuation (e.g., injury and severity data). EMED also includes longitudinal quality of life tracking data from the Wounded Warrior Recovery Project; follow-up is performed every six months.



EMED is used for a variety of purposes, to including threat reduction initiatives, real-time medical intelligence, vehicle and personal protective equipment effectiveness evaluation, and others. EMED infrastructure is currently funded by the Bureau of Medicine and Surgery Wounded Ill and Injured program. The Defense Health Board, the U.S. Navy Bureau of Medicine and Surgery, and the U.S. Marine Corps Headquarters have recommended that it be established through Program Objectives Memorandum funding and be designated as a program of record.¹⁸⁰

THE DEPARTMENT OF DEFENSE TRAUMA REGISTRY

The DoD Trauma Registry (DoDTR) was established within the Joint Theater Trauma System (JTS) to collect, store, and analyze trauma data from point of injury through discharge, for trauma patients receiving care at military treatment facilities (MTFs).⁶² The DoDTR collects, maintains, and reports all combat injury demographics, care, and outcomes for both military and civilian casualties (including amputation and limb salvage patients) into a single database.¹⁸¹ The data elements directly related to amputation included in the DoDTR include mechanism of injury, posture, abbreviated injury scale codes, International Classifications of Diseases, Ninth Revision (ICD-9) codes, ICD-9 procedures codes, and complications.¹⁸²

Data are abstracted into the DoDTR from the Joint Trauma System (JTS) in San Antonio, Landstuhl Regional Medical Center in Germany, Walter Reed National Military Medical Center (WRNMMC) and Womack Army Medical Center.¹⁸² Individuals must be admitted to a Level III MTF for inclusion in the DoDTR, and 100 percent of those available trauma admission records are included in the DoDTR.¹⁸¹ However, a limited number of sites are providing data to the DoDTR, and the registry does not include information after discharge from the acute care phase, such as further surgery, complications, and ongoing care and recovery. In addition, amputation classification is not well-defined within this registry.¹⁸² More recently, JTS has operationalized the Military Orthopaedic Trauma Registry and Pre-Hospital Trauma Registry as registries with specialty-focused inclusion criteria relevant to amputation-related injury.¹⁸³

THE EXTREMITY TRAUMA AND AMPUTATION CENTER OF EXCELLENCE REGISTRY

The National Defense Authorization Act (NDAA) 2009, Section 723 specifies that the DoD-VA Extremity Trauma and Amputation Center of Excellence (EACE) must “conduct research to develop scientific information aimed at saving injured extremities, avoiding amputations, and preserving and restoring the function of injured extremities. Such research shall address military medical needs and include the full range of scientific inquiry encompassing basic, translational, and clinical research.”⁷ Although not specified in the NDAA, EACE believes that “implicit in this Congressional mandate is the requirement to develop an extremity trauma and amputee registry to support the mandated Congressional research mission.”^{121(p2)} The EACE Registry (EACE-R) database was originally developed as the Amputee Data Base to track amputee patients evacuated from Southwest Asia to what was then Walter Reed Army Medical Center at the start of the recent conflicts and was subsequently transitioned to EACE and hosted by the Madigan Army Medical Center (MAMC).¹²¹ In 2012, the EACE began implementation of significant upgrades to the database in collaboration with MAMC. Phase one upgrades “stabilized the database system environment, created a larger data storage capability, made the database more ‘user friendly’ for users/providers, and transformed the ADB legacy system into



the current EACE-R.”^{121(p2)} Phase two upgrades began in February 2014, adding new capabilities, “to include access for VA staff members, the progression of amputation tracking, an enhanced reporting capability, and tracking of limb salvage patients.”^{121(p2)}

The EACE-R tracks civilian and military, conflict-related and non-conflict amputees, limb-salvage patients, and those who receive the Intrepid Dynamic Exoskeletal Orthosis™ (IDEO™) brace – thereby including nearly all Service members with service-related amputations that occurred during the current conflicts. EACE is working to integrate the EACE-R with adjunct databases to increase the capability to track all conflict-related amputees. Staff at the Advanced Rehabilitation Centers (ARCs) input data into the EACE-R from on-site patient information and the U.S. Transportation Command Regulating and Command and Control Evacuation System.¹²¹ Data include “basic demographic and amputation information, including level of amputation, injury mechanism, date of injury, dates of amputation(s), and delayed or elective amputations. Some historical clinical care information from point of injury through evacuation to [the continental U.S. is included], but it is not consistent across all patients.”¹²¹ EACE researchers embedded at the ARCs use the EACE-R for patient tracking; however, the database is “not yet robust enough to fully track rehabilitative and prosthetic care outcomes.”¹²¹ The EACE-R is also used to generate reports such as the EACE Amputee Monthly Statistics Report, which is the definitive source on the number of combat related amputees identified during Operation ENDURING FREEDOM (OEF), Operation IRAQI FREEDOM (OIF), and Operation NEW DAWN (OND).

The goal for the EACE-R is to longitudinally track extremity trauma and amputee patients through the entire continuum of care and rehabilitation; however, it is still missing key linkages to other data sources. EACE is working to access DoD electronic health records; allow for the input of real-time patient demographic, clinical, prosthetic and rehabilitative data; and incorporate data from the VA Amputation System of Care Rehabilitation Centers. Including this longitudinal data component would allow the EACE-R to track Service members and veterans from point of injury through the full spectrum of clinical and rehabilitative care for their lifetime. The EACE-R is not currently funded for this requirement as it is still in a phased improvement process. The EACE-R has potential to aid EACE in its congressional mission to develop and implement a comprehensive strategy for the mitigation, treatment, and rehabilitation of amputations, and to conduct research on amputee and extremity injury care. While progress has been made, the EACE-R still requires extensive development and resources to achieve these goals.

Finding 15: The EACE is not accomplishing the full mandate of its congressional charter⁷ as included in the National Defense Authorization Act of 2009.

Recommendation 15.1: The VA Under Secretary for Health and DoD Under Secretary for Personnel and Readiness should conduct an in-depth assessment of the organization and funding of EACE with the intent of optimizing EACE’s performance.

Recommendation 15.2: Based on the Board’s review, San Antonio would be the optimal geographic location for an enhanced EACE. The combined resources of the



San Antonio Military Medical Center, the Center for the Intrepid, the Institute for Surgical Research, the Audie L. Murphy Medical Center, the VA affiliate University of Texas Medical School, and the University of Texas San Antonio offer an impressively rich setting for this center of excellence.

THE COMPREHENSIVE COMBAT AND COMPLEX CASUALTY CARE PROGRAM MANAGEMENT AID

The Comprehensive Combat and Complex Casualty Care (C5) Program Management Aid (PMA), a patient tracking tool implemented at C5, aggregates and stores all C5 patient information sources into a single database, with an automated feed from the medical records.¹⁸⁴ The PMA allows providers to manage a portfolio of patients, and alerts providers to patient activity automatically. Further, the PMA provides reports to improve patient management and care coordination and tracks rehabilitation outcomes. PMA reports enable program oversight and patient population tracking, individual patient progression and treatment, and research studies. Finally, individual patient care patterns are aggregated to determine typical episodes of care for patients with specific types of injuries. The PMA can be used to forecast future capacity needs related to specific services such as prosthetic care, case management, and others. There are challenges in getting different systems to connect; however, this is the most advanced patient management tool across the three amputee care centers. Other challenges include the need for administrative support to input the data into the tool, the inability to tie costs to care data, and duplication with the EACE database.¹⁸⁵

THE FORECASTING AND CAPACITY EVALUATION TOOL

The Forecasting and Capacity Evaluation Tool (FACET) is an Excel spreadsheet with a user interface. The tool provides a sense of a patient's care episodes, but lacks definitions of effective care or good outcomes. FACET has not been implemented or validated at the Military Advanced Training Center (MATC) or the CFI, and challenges include differing information technology networks and protocols at the three ARCs.

THE VETERANS HEALTH ADMINISTRATION CORPORATE DATA WAREHOUSE

The Veterans Health Administration (VHA) Corporate Data Warehouse records diagnostic International Classification of Disease (ICD-9) codes and clinical procedural terminology codes, general demographic information, medical conditions, and health care utilization data (including fiscal year and location of service) for 100 percent of veterans receiving care in the VHA. Data are imported and updated from VHA workload capture systems into the Corporate Data Warehouse as soon as they are available; however, the database is only as good as the administrative data collection processes and coding procedures in place at the facility level, which can result in varied data quality. Data are available for clinical and administrative purposes at the facility and national levels. Data do not currently include performance-based functional outcome measures.

The VHA is developing a VHA Amputation Repository that will provide additional amputation-specific data for the veteran population in a centralized location. The ability to define and track the population with extremity trauma or salvaged limbs remains limited, as the current ICD-9



codes do not allow for detailed description of severe extremity traumas. The use of revised ICD-10 codes in the future will allow better definition of amputation-related data elements, including side and etiology of amputations.

THE DEPARTMENT OF VETERANS AFFAIRS' NATIONAL PROSTHETIC PATIENT DATABASE

The VA's National Prosthetic Patient Database records information on any prosthetic and assistive devices/items/services purchased or repaired for veterans, including L codesⁱ and the Healthcare Common Procedure Coding System. Data are entered into the database when purchases or repairs are processed, and procedures are in place to identify coding errors. The database can be used to quantify items provided to veterans, inform repairs and replacements, and forecast projected utilization trends and needs. The VHA is currently working on enhancements to timeline tracking and nomenclature for this database.

VETERANS BENEFITS ADMINISTRATION CORPORATE DATABASE UTILITIES

The Veterans Benefits Administration Database Utilities includes data on disabilities and evaluations for which service-connected disability compensation is received, including benefits such as clothing allowance, automobile allowance and adaptive equipment grants, housing adaptation grants, and Special Monthly Compensation. Claims-level data are collected on all claims filed for benefits when the claim is received and processed. Data are used in oversight, management, and process/quality improvement of the claims process. Data quality and completeness is dependent on the effectiveness of facility-level user input.

ⁱ "L codes are codes that bill for orthotics and prosthetics provided to patients. The 'L' identifies the code is for an orthotic or prosthetic, and the numbers define what body part and type of orthosis/prosthesis." ¹⁸⁶



5.3 OUTCOME MEASURES

Collecting and analyzing outcomes is an essential aspect of developing and providing evidence-based care.¹⁵ Although many tools and outcome measures and tools have been developed and demonstrated to be reliable and valid for amputees, a lack of consensus remains regarding which tools and measures are most appropriate for which specific populations.¹⁵ Mobility, function, and quality of life are the most common outcome domains used for amputee populations.¹⁵ The tools used to measure these domains are generally self-reported or observational tools.¹⁵ Examples of such tools are listed in Figure 13.

Of note, the development of outcome measures has been an area of increased attention, including the development of the Comprehensive High-Level Activity Mobility Predictor (CHAMP), intended for Service members with traumatic lower limb loss (a high functioning amputee population). The CHAMP measures current functional capability, systems to be addressed during rehabilitation, change in function over time, and readiness to return to higher-level activities.¹⁸⁷ The CHAMP utilizes several existing tests, and upon completion provides an overall CHAMP score. Tests included within CHAMP are the Single Limb Stance, where the amputee stands on each limb for a maximum of 30 seconds; the Medicine Ball Put, in which the amputee puts a six pound medicine ball as far as possible; the Edgren Side Step Test, in which the amputee steps sideways; the T-Test, in which the amputee runs forward, backward, and side to side in the shape of a T as fast as possible; and the Illinois Agility Test, in which the amputee runs forward and backward and around several cones as fast as possible. The CHAMP has been validated and found to have higher reliability than other assessment tools.¹⁸⁷⁻¹⁸⁹

5.4 RAPID CYCLE TRANSLATION OF RESEARCH AND TECHNOLOGY INTO PRACTICE

The rapid translation and application of research and technology into care has been central to rapid advances in amputee care during the current conflicts. This has been most notable in the areas of prosthetics and orthotics, limb salvage, transplants, and regenerative medicine.

Figure 13: Outcome Measurement Tools¹⁵

Self-reported measures:

- The Medical Outcomes Study Short Form 36-Item Health Survey
- Legro and colleagues' prosthesis evaluation questionnaire
- The locomotor capabilities index
- The sickness impact profile
- The questionnaire for persons with a trans-femoral amputation
- The Trinity Amputation and Prosthetic Experience Scale

Performance-based measurement tools and devices:

- The Comprehensive High-Level Activity Mobility Predictor (CHAMP)
- The "get up and go" test
- The 6-minute walk test
- Gailey and colleagues' amputee mobility predictor
- The disabilities of the arm, shoulder, and hand (DASH) questionnaire
- The box and block test
- The Jebsen-Taylor hand function test
- The step activity monitor
- Three-dimensional gait and motion analysis
- Energy consumption measurements

Adapted from Pasquina, et al 2009.



TECHNOLOGY AND ADVANCEMENTS IN PROSTHETICS

No prosthetic can replace what a Wounded Warrior sacrifices in combat; however, prosthetic limbs can make it possible for amputees to meaningfully engage in activities as they desire. Prosthetic limbs have been a significant focus during the current conflicts, not only continuing to advance lower limb prostheses, but also because of the relatively large number of upper limbs lost as a result of duty in Iraq and Afghanistan, stimulating the advancement of upper limb prostheses which had previously lagged behind in development.¹⁹⁰ Prosthetic options include electrically powered, body-powered, and hybrid prostheses.¹²⁷ Task-specific lower and upper limb prostheses are available for activities such as running, rock climbing, fishing, and bicycle riding.^{127,191} Another popular prosthetic option is a passive or cosmetic restoration, which provides a prosthetic that is similar in appearance to the lost limb, but often does not provide grasping capabilities.¹²⁷

During a visit to one of the ARCs, a prosthetist demonstrated a dynamic prosthetic limb in development, on which the skin fit can be quickly and easily expanded and contracted as body mass changes over the course of hours or days. This, and other advances in the various aspects of prosthetics and orthotics over the past decade and a half, has largely been possible through rapid patient application, testing, and feedback. Because of heavy reliance on prosthetics and orthotics, technology and material sciences are fundamental to amputee care in a way not traditional to medicine, and integration between the fields is critical. “Technological advances in prosthetic design not only significantly improve patient satisfaction and functional outcomes, but also facilitate progression in rehabilitation.”^{15(p14)}

Upper limb prosthetics are considered more difficult to create than lower limb prosthetics. Therefore, there are far fewer prosthetic options available for the upper limb than for the lower limb, and the options are still considered inadequate by leading experts.¹⁹² The difficulty with upper limb prosthetics lies in the numerous small joints in the fingers and hands, the dexterity and variety of functions that the hands perform, and the relatively lightweight and small size of the upper extremities. The state of the art in upper limb prosthetics is myoelectric prostheses, which are motorized devices controlled using muscle signals.¹⁹² This process works fairly well with more distal amputations; however, with higher levels of amputation, the muscles usually used for prosthesis control are removed, and upper arm or chest muscles must be trained to operate the prosthesis.¹⁹² Body-powered prostheses, which work by harnessing shoulder motion to control movement of the device, are still commonly used today because of their relative simplicity and robustness.¹⁹²

Targeted muscle re-innervation (TMR) is a relatively recent area of development. TMR utilizes the arm nerves that transmit the neural signals used to control the arm—and still exist even after the arm is amputated—moves those nerves to new muscles, and then lets them re-innervate, or grow into the new muscles. After a few months of re-innervation, these muscles produce signals that can be used to give amputees intuitive thought control of a robotic arm.¹⁹² With intuitive control, an amputee can think “open hand” and the hand opens. An unexpected finding in a TMR study was the first patient in history who is able to feel with his prosthetic arm. As a result of this surprising finding, sensory re-innervation studies are now underway. Pattern recognition control is the most advanced control system available to upper limb amputees.¹⁹²



Marking a dramatic advance in upper limb prosthetic technologies, the Food and Drug Administration in May 2014 approved the DEKA Gen 3 Prosthetic Arm for use. Development of the DEKA Arm was funded by the Defense Advanced Research Projects Agency (DARPA) as part of its focus on advancing upper limb prosthetics. The arm can be used by an amputee to perform such delicate and refined tasks as scratching his or her nose, picking up a grape and eating it, and fixing his or her hair.¹⁹³ The DEKA Arm is not brain controlled at this point; however, DARPA is seeking funding for the next phase which would seek to make the arm neuro-controlled with sensation. The DEKA Arm brought dramatic technological advancements; however, it comes at a high cost. The cost of the full arm is estimated at \$100,000, and reimbursement remains a challenge.¹⁹³

Another advanced upper limb prosthetic in clinical trial at WRNMMC is the Johns Hopkins Applied Physics Laboratory Modular Prosthetic Limb. This limb has up to 26 degrees of freedom and training for its use is done using a Virtual Integrative Environment (VIE). The VIE uses an avatar (computer virtual reality-generated upper limb) coupled with electromyography recording from residual limb muscles to train amputees to use the limb and to drive limb movements after discreet muscle activation patterns are recorded.^{194,195}

Lower-limb prosthetics have advanced much more quickly, and advances have been focused on component design as well as socket fabrication. After amputation, lower limbs are left with complex scarring, and rapidly change in volume¹⁵ because of fluctuations in water weight and weight gain. Because of this variability, the point of interface between the prosthesis socket and the residual limb is a critically important aspect of prosthetic design and fitting. Socket design, suspension, liners, socks, and sleeves vary depending on the limb and level of amputation as well as specific injury healing needs, and desired activities of the amputee. When appropriate, gel liners can provide additional comfort and protection through cushioning against socket pressure and shear reduction.¹⁴⁵ Prosthetic socks and sleeves are the interface between the residual limb and the prosthesis and serve multiple purposes, including adjusting the fit of the prosthetic with fluctuations in limb volume.¹⁴⁵ Technological advances, such as the IDEO™, the C-leg, and the expandable prosthetic limb increase the range of capabilities, enhance function, and facilitate more rapid and effective rehabilitation.¹⁵

REGENERATIVE MEDICINE

Regenerative medicine refers to the biological repair and regrowth of organs and tissues. In the context of the treatment of extremity injuries, regenerative medicine focuses on developing new options for the repair and regeneration of critical bridging tissues to allow for saving a limb and decreasing the need for amputation.¹⁹⁶ This is generally focused on the preservation or restoration of the following:

- Bridging bone and connective tissue (i.e., cartilage, tendon, ligament) and supportive soft tissues (i.e., muscle) to re-establish stability and enable mobility along the entire limb;
- Bridging vascular defects and restoring blood flow to regions compromised by trauma to enable limb recovery and support bone and soft tissue regeneration;
- Bridging peripheral nerve gaps to afford both motor and sensory restoration and appropriate muscle re-innervation which may improve downstream rehabilitation and stave off muscle atrophy; [and]



- Regenerating healthy ‘high quality’ pigmented skin complete with sweat glands to cover the injured area and to provide a durable barrier to infection.¹⁹⁶

LIMB SALVAGE, EXOSKELETONS, AND ORTHOSES

Once a limb is saved, exoskeletons and orthoses are used to enhance functional use of that limb. Exoskeletons and orthoses are mechanical devices worn tightly fitting on a salvaged limb.¹⁹⁷

The device works in concert with the individual’s movements, to assist (orthotics), or to augment normal function (exoskeletons) of an injured extremity.¹⁹⁷ Some devices extend a human limb to increase length and displacement, and others decrease energy expenditure or increase strength and endurance.¹⁹⁷

Research regarding exoskeletons is ongoing and rapidly advancing. A 2009 study of an elastic leg exoskeleton “substantially decreased the metabolic demands of human hopping” and has “the potential to vastly change the biomechanics and metabolic costs of running.”^{198(p677)} A pilot study of an elastic knee exoskeleton published in 2013 suggests different responses between trained and casual runners in knee stiffness when using the exoskeleton, and recommends further research to identify and define the potential relationship between past running training and effective utilization of an exoskeleton. Such a relationship could indicate limitations on the applicability of assistive devices and interventions.¹⁹⁹

Limb salvage alternatives for patients with traumatic extremity-threatening injuries have dramatically improved in recent years; historically patients often elected amputation over limb salvage.¹⁶⁹ A 2010 meta-analysis of amputation versus limb salvage documented the lack of consensus regarding whether a patient should be offered amputation or limb salvage, on what basis, and even what possible outcome the patient should expect from a successful procedure.²⁰⁰ The study found that among Wounded Warriors with traumatic lower extremity injuries, limb salvage was psychologically more acceptable than amputation, even though the physical outcome for both was more or less the same.²⁰⁰

One device exemplifying innovation in this area is the IDEO™, developed by a practitioner based on his experience at CFI and designed to aid Wounded Warriors who are able and choose to salvage an injured leg rather than amputating it. The IDEO™ has demonstrated improved mobility outcomes as compared to other bracing options and reduces pain considerably.¹⁰¹ Growing adoption of the IDEO™ has significantly increased Wounded Warriors’ selection of limb salvage over amputation¹⁰¹ and thus has broadened the spectrum and scope of amputee care to include those with traumatic extremity injuries with salvaged limbs.

The IDEO™ is a hallmark example of innovative technologies to meet patient needs that was developed in the interdisciplinary setting and fostered by ongoing and dynamic patient-provider-practitioner communication. In response to patient dissatisfaction with limb salvage patient outcomes,¹¹¹ the *Return-to-Run* (RTR) clinical pathway was developed and implemented in the DoD ARCs, first in CFI in 2011, as an effort to facilitate attainment of the high performance goals of Wounded Warriors who experienced limb-threatening injury to the lower extremities, but are able to salvage the limb.^{169,201} The RTR clinical pathway is multidisciplinary, involving the Orthopaedic, Physical Therapy, and Prosthetics departments,¹³⁷ and uses an energy storage and return ankle foot orthosis, the IDEO™, and high-intensity sports medicine-based

rehabilitation.¹⁶⁹ Care for limb salvage patients utilizing the RTR “begins early in a patient’s treatment, before full weight bearing has been authorized and while the patient is still using circular external fixation.”^{137,169} At this early stage, rehabilitation is focused on strength, horizontal plyometrics, power, agility, and retraining on how to run.^{137,169} Patients are put in recovery and rehabilitation cohorts, serving as informal peer support and allowing those early in the process to see others further along.^{137,169} Once full weight bearing is authorized and circular external fixation removed, the patient is fit with an IDEO™ and progresses to more dynamic impact exercise, vertical plyometrics and strength, agility, and further run retraining.^{137,169} Once fitted with an IDEO™, the RTR clinical pathway takes 12 weeks to complete.¹⁶⁹

The IDEO™ is a “custom carbon fiber energy storage and return ankle foot orthosis...made to withstand daily use and high-performance activities.”^{137(p e70)} The patellar tendon-bearing design of the IDEO™ with its modular foot plate system allows the IDEO™ to unload specific segments of the lower extremity, enabling most patients who have pain while weight-bearing to attain a near pain-free state.²⁰¹ Therefore, the IDEO™ is advantageous for those patients with limited or no ankle and foot mobility, as its design is similar to an amputation running prosthesis, providing energy through the posterior strut.²⁰¹ The IDEO has been demonstrated, in tandem with a “structured and aggressive rehabilitation program with a multidisciplinary approach,” to allow patients who have undergone lower extremity limb salvage to return to high levels of athletic activities, including running and sports, previously not attainable.¹⁶⁹ The wearer of the IDEO™ with the military uniform can be seen in Figure 14.

Figure 14. The wear of the IDEO in military uniform; the IDEO device^{137,169}



From Patzkowski, et al, 2012 and Blair, et al, 2014.

HAND TRANSPLANT

Hand transplant is an area of recent advancement and exploration, having potential for dramatic impact on the quality of life for upper limb amputees (17 percent of amputees in the current conflicts).²⁰² However, global experience in hand transplantation is extremely limited, at only 72 patients, totaling 107 hands, with skin rejection remaining a common challenge. Most physicians performing hand transplantation resort to immunosuppression drugs to mitigate skin rejection, despite the significant adverse effects. The Armed Forces Institute for Regenerative



Medicine has sponsored one medical team in conducting a trial to test an approach for hand transplantation that reduces the length of time and quantity of immunosuppressant drugs that are used. This trial followed six patients over 48 months, with the post-transplant course lasting three to five years. This approach is still early in its development and the patient screening and selection process is stringent. In this first trial, one patient was non-compliant with treatment, which resulted in rejection and eventual removal of the transplanted hand. However, the transplants in the other five recipients have been very successful.²⁰²

A substantial benefit of hand transplantation over use of prostheses is the ability to restore the whole capability, including touch and feel, as well as improving self-confidence and aesthetics.²⁰² Though the initial cost of hand transplantation is \$250,000 to \$500,000, the longer-term rehabilitation phase costs do not exceed the cost of traditional amputee care. An additional benefit of hand transplantation is reduction or elimination of neuroma pain, to the extent that the recipient of a hand transplant is off pain medication relatively quickly after the transplant.²⁰²

Finding 16: The research and care processes, rapid prototyping, and applied research that have been achieved in recent years were lacking at the beginning of the conflicts. However, the close proximity of research and clinical personnel has led to breakthroughs in research, general medical care, and prosthetic care.

Recommendation 16: DoD should maintain and disseminate lessons learned from tactical combat casualty care and the rapid cycle research in amputee care, including the colocation of research and clinical care to ensure the effective and timely application of innovations in the delivery of care and to optimize resources.

5.5 RESEARCH GAPS

While tremendous progress has been made in research related to amputee care during the current conflicts, research gaps remain. New areas of opportunity have emerged through recent technological and medical advancements and shifting needs of the current amputee population highlight new areas for research.

Through its review, the Subcommittee identified a lack of understanding of the long-term morbidity, mortality, and risks associated with living with major limb amputation to be a primary gap of major importance. A thorough understanding of the long-term outcomes, needs, and quality-of-life issues for amputees is important for program planning and development. Further research into “mitigating of the development of secondary injuries (i.e., osteoarthritis, lower back pain, and cardiovascular disease)”^{203(p3)} will be critical in DoD’s ability to provide targeted and appropriate lifelong care for this new generation of injured Service members.

There are also many scientific and technological breakthroughs on the horizon that could dramatically affect amputee care in the future if additional research resources and attention are devoted to this effort. For example, advances in three-dimensional printing may allow for individualized patient and function-specific customization, as well as rapid manufacturing of prosthetic and orthotic devices.⁹⁰ In addition, the development of a neural interface for powered limb prostheses using information fusion, residual limb-lengthening systems, and powered orthotic systems will continue to provide better mobility and functionality for upper limb



amputees.¹⁹² Moreover, the incidental discovery that TMR reduces neuroma pain has led to further investigations of its use as a treatment for neuroma pain.¹⁹² Furthering targeted sensory feedback could return to amputees the feeling in their missing limbs.¹⁹²

Current promising treatment approaches still require refinement. For example, percutaneous skeletal attachment of prostheses, commonly known as osseointegration, is currently used for lower limb amputees who are not candidates for a prosthesis. With osseointegration a metal abutment connects directly to a load bearing bone (e.g., the femur). Gaps still remain in the science of socket technology and prosthetic interface, such as osseointegration, which has lagged behind more popular prosthetic advancements, but remains critical for prosthetic use.²⁰³

Continuing to advance both upper and lower extremity prosthetic technology is important. Future areas for development include power lower limb prostheses focused on mechatronics and control and sensory feedback for prosthetic limbs.¹⁹² Additional gaps to address through further research identified by the C5 staff include the immunology of hand transplants, as well as broader regenerative medicine and tissue reengineering, and advanced prosthetics.

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APPENDICES

APPENDIX A. LETTER OF REQUEST TO THE DEFENSE HEALTH BOARD

1



PERSONNEL AND
READINESS

UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, DC 20301-4000

JUN 20 2013

MEMORANDUM FOR PRESIDENT, DEFENSE HEALTH BOARD

SUBJECT: Request to the Defense Health Board Pertaining to Sustaining and Advancing
Amputee Care

In a memorandum dated June 5, 2013 (attached), the Chairman of the Joint Chiefs of Staff indicated the sustainment of current practices and the continuing advancements in treatment and rehabilitation of amputees should be a high priority for the Defense Health Board (DHB). He recognizes the need to ensure there is no loss of knowledge and skills due to the drawdown of the Afghanistan conflict with the welcomed reduction of war-related amputations.

I request DHB review the full spectrum of amputee care, and define a strategy for preserving and continuing these advancements, identifying the best possible care to our beneficiaries. Your thoughtful advice and guidance would greatly assist us in this matter. Please provide a response on these items to the Assistant Secretary of Defense for Health Affairs. Thank you for the highly professional and considered work of the Board and for your efforts on this new initiative.

Jessica I. Wright
Jessica I. Wright
Acting

Attachment:
As stated

cc:
Assistant Secretary of Defense
for Health Affairs

2



APPENDIX B. LETTER OF ENDORSEMENT FROM THE CHAIRMAN OF THE JOINT CHIEFS OF STAFF



CHAIRMAN OF THE JOINT CHIEFS OF STAFF
WASHINGTON, D.C. 20318-9999

CM-0147-13
5 June 2013

MEMORANDUM FOR ASSISTANT SECRETARY OF DEFENSE FOR HEALTH AFFAIRS

SUBJECT: Sustaining and Advancing Amputee Care

1. This memorandum responds to the Defense Health Board's request for a formal endorsement of the importance of subject care.
2. As the conflict in Afghanistan winds down, I recognize the importance of preserving the knowledge, skills, and advances made in caring for amputees over the past decade. I am mindful that the welcome anticipated reduction in war-related amputations may also be attended by the loss of knowledge and lessons learned that have brought us to the current level of capability. As such, sustaining current practices and continuing advancements in treatment and rehabilitation should be a high priority for the Defense Health Board.
3. My point of contact is Major General Douglas J. Robb, USAF; Joint Staff Surgeon, J-4; 703-697-4346.

A handwritten signature in black ink, appearing to read "Martin E. Dempsey".
MARTIN E. DEMPSEY
General, U.S. Army



APPENDIX C. TERMS OF REFERENCE

Defense Health Board Review of the Sustainment and Advancement of Amputee Care

TERMS OF REFERENCE

These terms of reference establish the objectives for the Defense Health Board's (DHB) review of amputee care, including the definition of strategies to enhance best practices and sustain advancements in treatment and rehabilitation. The terms outline the scope of the Board's examination as well as the Board's methodology for responding to the Department of Defense's (DoD) request.

Mission Statement: The DHB will conduct a comprehensive review of the full spectrum of amputee care, and define a strategy for sustaining and continuing these advancements, identifying the best possible care for DoD beneficiaries.

Issue Statement: Because of advancements in military medicine, DoD has created a shift in the management of the amputee patient population to a focus on ability as opposed to disability. Improved survival rates in combat have increased the volume of young and high- performing amputees. In treating this new patient population, DoD has developed significant advancements in amputee care and rehabilitation. With current military conflicts winding down, it will be important to maintain and extend the current level of expertise in amputee care within the Military Health System. On June 20, 2013, the Acting Under Secretary of Defense for Personnel and Readiness endorsed a request from the Chairman of the Joint Chiefs of Staff for the DHB to review the spectrum of amputee care and to recommend a strategy for sustaining and continuing these advancements.

Objectives and Scope: The DHB will address the following aims regarding amputee care in its report:

1. Review the full spectrum of amputee care;
2. Identify and list sources of best practices at the levels of field trauma care, initial surgery, reconstructive procedure, and rehabilitation;
3. Determine how to maintain continued advancements as the drawdown of Service members takes place;
4. Identify areas of clinical and technologic research for DoD to support; and,
5. Determine strategies to ensure that the military sustains the existing level of excellence.

Methodology: The Health Care Delivery Subcommittee will review the spectrum of amputee care and strategies to maintain and advance the current level of excellence. As needed, members



will receive briefings from subject matter experts, DoD personnel involved in amputee care efforts, and amputees themselves. The members will review the literature and information received from briefings, conduct site visits as needed, and present their preliminary findings and recommendations to the DHB for consideration and deliberation. The DHB will deliberate the findings, during which time members may propose additional recommendations, and vote on these collective recommendations in an open public session.

Deliverable: The DHB will deliberate the final findings and recommendations presented by the Subcommittee in 2014 and produce the final report immediately following for presentation to the Department. The Subcommittee will provide progress updates to the Board at each DHB meeting before then.

Membership: The Health Care Delivery Subcommittee members will conduct the primary investigation and will consult subject matter experts as needed.

Support:

1. The DHB office will provide any necessary administrative, analytical, research and logistical support for the Subcommittee and Board.
2. Funding for this review is included in the DHB operating budget.



APPENDIX D. MEETINGS AND BRIEFINGS

July 24, 2013

Teleconference

The Defense Health Board President, Second Vice President of the Defense Health Board and Chair of the Health Care Delivery Subcommittee, and GEN (Ret) Frederick Franks discussed the tasking, scope of the review and report, relevant publications and site visits, and a way ahead for the Health Care Delivery Subcommittee. There were no briefings at this meeting.

August 14, 2013

Teleconference

Members discussed the tasking, scope of the review and report, and relevant briefers and site visits, as well as the way ahead for the Subcommittee. There were no briefings at this meeting.

September 25, 2013

Walter Reed National Military Medical Center (WRNMMC), Bethesda, Maryland

Members spoke with Wounded Warriors who had sustained amputations and their family members; and conducted a site visit of WRNMMC amputee care facilities. Members also heard the following briefings:

- *Overview of Amputee Care in the Department of Defense/Department of Veterans Affairs*
COL (Ret) Charles Scoville, Chief, Department of Rehabilitation, WRNMMC
- *Facilities*
COL (Ret) Charles Scoville, Chief, Department of Rehabilitation, WRNMMC
- *Orthopedic Trauma Surgery*
COL Romney Anderson, Chief, Department of Orthopaedics, WRNMMC
- *Prosthetics*
Mr. David Laufer, Chief, Orthotics and Prosthetics, WRNMMC
- *Peer Visitation*
Mr. Jim Mayer, Peer Visitor, Wounded Warrior Project
- *Psychiatry*
Dr. Hal Wain, Chief, Preventive Psychiatry, WRNMMC
- *Physical Medicine and Rehabilitation*
Dr. Paul Pasquina, Residency Director and Chair, Physical Medicine & Rehabilitation, Uniformed Services University of the Health Sciences, WRNMMC
- *Pain Management*
Dr. Paul Pasquina, Residency Director and Chair, Physical Medicine & Rehabilitation, Uniformed Services University of the Health Sciences, WRNMMC



- *Wound Care*
Ms. Kara Couch, Nurse Practitioner, Complex Wound and Limb Salvage Center, Department of General Surgery, WRNMMC
- *Global Outreach and Diplomacy*
MAJ Sarah Mitsch, Occupational Therapist, Womack Army Medical Center
- *Update on the Future of DoD Amputee Care*
COL (Ret) John Shero, Director, DoD-VA Extremity Trauma & Amputation Center of Excellence (EACE), HQ, U.S. Army Medical Command (USAMEDCOM)

October 24, 2013

Teleconference

Members discussed the draft terms of reference and guiding principles, reviewed key findings from the WRNMMC site visit, and planned the way ahead. There were no briefings at this meeting.

November 15, 2013

Teleconference

Members reviewed the draft terms of reference and guiding principles and discussed the upcoming site visit to San Antonio as well as the way ahead. There were no briefings at this meeting.

December 18-19, 2013

Center for the Intrepid (CFI) at San Antonio Military Medical Center (SAMMC) and U.S. Army Institute of Surgical Research (ISR) Burn Center, San Antonio, Texas

Members spoke with Wounded Warriors who had sustained amputations and their family members; conducted a site visit of CFI, including a demonstration on the sport court; and toured the ISR Burn Center. Members also heard the following briefings:

- *Commander's Welcome*
COL Kyle Campbell, Commander, BAMC
- *Overview of EACE*
COL (Ret) John Shero, Director, EACE
- *Current Mission/Future Vision for Amputee Care*
COL Donald Gajewski, Director, CFI; and
COL (Ret) Rebecca Hooper, Program Manager, CFI
- *Limb Salvage and IDEO Program Overview*
COL Donald Gajewski, Director, CFI
- *Demo of Military Performance Lab and CAREN*
Dr. Jason Wilken, Military Performance Lab Director, CFI
- *Future Research Initiatives*



Dr. Jason Wilken, Military Performance Lab Director, CFI

- *Clinical Uses of Technology*
Dr. Alison Linberg, Research Physical Therapist at WRNMMC, EACE
- *Challenges for the Future in Community Reintegration and Case Management*
Heather Miller, CTRS, Recreation Therapist, CFI; and
Kathy O'Neal, RN, CCM, Case Manager, CFI
- *VA Collaboration Potential*
COL (Ret) Rebecca Hooper, Program Manager, CFI
- *ISR Burn Center Overview*
COL Cancio, Director, Burn Center, ISR
- *ISR Burn Center History and Operational Details*
COL Cancio, Director, Burn Center, ISR
- *ISR Burn Unit Budget Briefing*
COL Renz, Deputy Chief of Clinical Services, ISR

January 13, 2014

Teleconference

Members reviewed the draft report outline, the way ahead, and additional data requests. There were no briefings at this meeting.

February 10-11, 2014

Comprehensive Combat and Complex Casualty Care (C5) Program at Naval Medical Center San Diego (NMCSO) and Naval Health Research Center (NHRC), San Diego, California

Members spoke with Wounded Warriors who had sustained amputations and their family members; conducted a site visit of C5; and toured the Warfighter Performance Lab at NHRC. Members also heard the following briefings:

- *In-Brief with NMCSO Leadership*
RDML Bruce Gillingham, Commander, NMCSO
- *C5 Evolution of Care/Shifting Mission*
LCDR Robert Sheu, Head, Physical Medicine and Rehabilitation Department/Medical Director, C5, NMCSO; and
Ms. Jennifer Town, C5 Program Director
- *Orthopedics/Prosthetics Update*
CDR Dave Dromsky, Orthopaedics-Trauma Staff Surgeon, Orthopaedics Department, C5, NMCSO; and
Brian Zalewski, Head, NMCSO Prosthetics
- *Physical Therapy/Occupational Therapy Update*
CDR Kristin Hodapp, Department Head, Physical Therapy/Occupational Therapy, NMCSO; and
CAPT Mike Rosenthal, Assistant Department Head, Physical Therapy/Occupational Therapy, NMCSO



- *Mental Health/TBI Update*
Dr. Colleen Leners, Traumatic Brain Injury Program Manager, NMCSO; and
Dr. Mark Monahan, Staff Neuropsychologist, C5, NMCSO
- *Health/Wellness Update*
Ms. Helen Metzger, Head, Health and Wellness Department, NMCSO
- *Current Initiatives (VA/NMCSO JIF, INTEGRA Center, PMA and FACET Tools)*
CAPT Michael Finch, Director, Health Care Business, NMCSO;
Ms. Town, C5 Program Director;
Ms. Megan Walsh, Business Manager, C5, NMCSO;
Ms. Qiani Brown, Health Systems Specialist, Healthcare Business, NMCSO; and
Mr. Michael Marks, Healthcare Analyst, Improvement Path Systems, Inc., Contract Support to NMCSO
- *Project CARE*
CAPT Craig Salt, Department of Plastic Surgery, NMCSO; and
Ms. Octavia Harris, Project CARE Program Manager, NMCSO
- *Current Research/Studies*
CAPT Mike Rosenthal, Assistant Department Head, PT/OT, NMCSO;
Ms. Marilyn Wyatt, Gait Analysis Laboratory, C5, NMCSO;
CDR Dromsky, Orthopaedics-Trauma Staff Surgeon, Orthopaedics Department, C5, NMCSO; and
Dr. John Malone, Head, Clinical Investigations Department, NMCSO
- *In Brief with NHRC Leadership*
CAPT Lanny Boswell, Executive Officer, NHRC
- *Combat Trauma Registry / Expeditionary Medical Encounter Database*
Dr. Michael Galarneau, Department Head, Medical Modeling and Simulation Department, NHRC
- *Amputee Research, Studies and Findings*
Dr. Ted Melcer, Research Psychologist, Medical Modeling and Simulation Department, NHRC;
LCDR Jose Dominguez, Research Physical Therapist, Warfighter Performance Department, NHRC;
LT Seth Reini, Research Psychologist, Warfighter Performance Department, NHRC; and
Dr. Pinata Sessoms, Biomechanist, Warfighter Performance Department, NHRC
- *Future Directions: Longitudinal Efforts/Long Term Outcomes “Wounded Warrior Recovery Projects” Collaborations/EACE*
Dr. Michael Galarneau, Department Head, Medical Modeling and Simulation Department, NHRC

March 17, 2014

Teleconference

Members discussed the tasking, the way ahead, and additional individuals to speak with, including Wounded Warriors and DoD leadership. There were no briefings at this meeting.



April 28, 2014

Teleconference

Members spoke about the Navy-Marine Corps Relief Society Combat Casualty Assistance Visiting Nurse (CCAVN) Program and plans for the upcoming meetings and the briefers they would be hearing from. They also identified remaining information gaps. There were no briefings at this meeting.

May 21-22, 2014

Defense Health Headquarters, Falls Church, Virginia

Members heard the following briefings:

- *Amputee Coalition*
Ms. Sue Stout, Interim Director and Chief Executive Officer, Amputee Coalition
- *Research Activities in Prosthetics Research and Development*
Dr. Todd Kuiken, Director, Center for Bionic Medicine and Amputee Services, Research Institute of Chicago; Feinberg School of Medicine, Northwestern University
- *DARPA Amputee Care Research*
COL (Ret) Geoff Ling, Director of the Biological Technologies Office, Defense Advanced Research Projects Agency (DARPA)
- *Amputee Rehabilitation & Research-CHAMP Test*
Dr. Robert Gailey, Professor, Department of Physical Therapy, Miller School of Medicine, University of Miami Health System; Research Department, Miami VA Medical Center
- *Hand/Arm Transplant Surgery for Wounded Warrior*
Dr. W. P. Andrew Lee, Chief, Plastic and Reconstructive Surgery, Johns Hopkins University School of Medicine
- *Discussion with the BADER Consortium*
Dr. Steven Stanhope, Director, BADER Consortium
- *Discussion of NIH Amputee Care Research and Gaps*
Dr. Ralph Nitkin, Acting Director, National Center for Medical Rehabilitation Research; (Eunice Kennedy Shriver) National Institute of Child Health and Human Development (NICHD), National Institutes of Health (NIH); and
Dr. Daofen Chen, Program Director, Systems and Cognitive Neuroscience, National Institute of Neurological Disorders and Stroke (NINDS), NIH
- *Overview of VA Amputation System of Care and VA Orthotic and Prosthetic Services*
Dr. Lucille Beck, Deputy Chief Patient Care Services Officer, Rehabilitation and Prosthetic Services, VA; and
Dr. Joseph Miller, Director, VHA Orthotic and Prosthetic Clinical Services, VA
- *Overview of Orthotic and Prosthetic Research*
Dr. Patricia Dorn, Director, Rehabilitation Research and Development, VA
- *VA/DoD Collaborations*
Dr. Joseph Webster, Medical Director for VHA Amputation System of Care, VA; and



Dr. Billie Randolph, Deputy Director, DoD-VA Extremity Trauma and Amputation Center of Excellence (EACE)

- *VA Benefits for Amputee and Limb Salvage Care*
Ms. Edith Bean, VA Regional Liaison, TRICARE Regional Office-N, VHA Office of Interagency Health Affairs, Department of Veterans Affairs (VA); and
Ms. Kristin Cunningham, Director, Business Policy, Veterans Health Administration Chief Business Office, VA
- *Cost Discussion*
Dr. Robert Opsut, Director, Program Review and Evaluation, Health Budgets and Financial Policy, Office of the Assistant Secretary of Defense for Health Affairs

June 9-10, 2014

Defense Health Headquarters, Falls Church, Virginia

Members discussed the tasking and received briefings and engaged in strategy discussions as follows:

- *Strategy Discussion*
Lt Gen Douglas Robb, Director, Defense Health Agency
- *Advances in Amputee Rehabilitation: Moving Wearable Technology from the Expert to Non-Expert User*
Dr. Leia Stirling, Assistant Professor, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology
- *Discussion with the Joint Staff Surgeon*
MG Nadjia West, Joint Staff Surgeon
- *Strategy Discussion*
Dr. Jonathan Woodson, Assistant Secretary of Defense for Health Affairs
- *Navy-Marine Corps Relief Society Combat Casualty Assistance (CCA) Visiting Nurse Program*
Ms. Ruthi Moore, Director of Nursing, Navy-Marine Corps Relief Society
- *Advances Relevant to Service Members and Veterans with Limb Amputations*
Dr. Rory Cooper, Distinguished Professor, FISA/PVA Chair; Director, Human Engineering Research Laboratories, University of Pittsburgh

June 30, 2014

Teleconference

Members discussed the tasking and spoke with the DHB Trauma and Injury Subcommittee about parallels between the theater trauma lessons learned tasking and the amputee care tasking. There were no briefings at this meeting.

July 21, 2014

Teleconference



Members discussed the tasking and way ahead. There were no briefings at this meeting.

August 28, 2014

Teleconference

Members discussed the tasking. There were no briefings at this meeting.

September 23-24, 2014

Defense Health Headquarters, Falls Church, Virginia

Members discussed the tasking and received briefings and engaged in strategy discussions as follows:

- *Briefing and Discussion*
LTC Benjamin Potter, Vice Chair, Orthopaedic Surgery, Chief Orthopaedic Surgeon, Amputee Patient Care Program, Department of Orthopaedics, Walter Reed National Military Medical Center Vice, Chair (Research) & Associate Professor Department of Surgery, Uniformed Services University of the Health Sciences
 - *DoD/VA Extremity Injury and Amputation Center of Excellence*
Mr. John Shero, Director, EACE; CAPT Lanny Boswell, Chief, Research and Surveillance Division, DoD-VA EACE; and Dr. Billie Randolph, Deputy Director, EACE.
 - *Review of Cost Analysis*
Dr. Robert Opsut, Director, Program Review and Evaluation, Health Budgets and Financial Policy, Office of the Assistant Secretary of Defense for Health Affairs
 - *Staffing Projection and Patient Load Management Forecasting and Capacity Evaluation Tool (FACET) and Patient Management Tool Used ad C5*
Mr. Timothy Ward, Deputy Director, Program Analysis and Evaluation Directorate, Bureau of Medicine and Surgery, Office of the Navy Surgeon General

October 8, 2014

Teleconference

Members discussed the tasking. There were no briefings at this meeting.

October 30, 2014

Teleconference

Members discussed the tasking and way ahead. There were no briefings at this meeting.



November 21, 2014

Teleconference

Members discussed the tasking and future funding for amputee care research. Members engaged in a discussion with Dr. Terry Rauch regarding DoD research funding.

December 11, 2014

Teleconference

Members met with the Surgeons General or their designated officers to discuss the tasking and DoD's commitment to amputee care in the future.

December 15, 2014

Teleconference

Members discussed the tasking. There were no briefings at this meeting.

January 13, 2015

Teleconference

Members discussed the tasking. There were no briefings at this meeting.

January 27, 2015

Teleconference

Members discussed the tasking. There were no briefings at this meeting.

February 3, 2015

Teleconference

Members discussed the tasking and finalized the Findings and Recommendations at the meeting.



APPENDIX E. TIMELINE OF CRITICAL EVENTS IN DoD AMPUTEE CARE

2001	<ul style="list-style-type: none"> DoD/VA/Civilian Panel of Experts on Amputee Care Extremity War Surgery Course; Three Times Yearly
2003	<ul style="list-style-type: none"> Ertl Consensus Conference Amputee Patient Registry Defense Health Board Subcommittee for the Care of Individuals with Amputation and Functional Limb Loss Charter Submitted WRAMC Renovation
2004	<ul style="list-style-type: none"> Report to Congress: Infrastructure Improvement Plan for U.S. Army Amputee Patient Care Program Columbia 2004, 2005, 2008 First DoD/VA Military Advanced Amputee Skills Training Course VA/DoD Summit Technology Transfer MILCON appropriation for MATC
2005	<ul style="list-style-type: none"> BAMC Renovation First amputee patient returns to Iraq Military Amputee Research Program Established
2006	<ul style="list-style-type: none"> Iraq Jan. – Jun. 2006 Orthopedic Trauma Research Program Military Extremity Trauma Amputee Vs Limb Salvage Project Targeted Muscle Reinnervation RIC
2007	<ul style="list-style-type: none"> CFI, San Antonio, TX Opened X2 Microprocessor Knee MATC, Washington, DC Opened C5, San Diego, CA Opened Sri Lanka
2008	<ul style="list-style-type: none"> DoD/VA Clinical Practice Guideline Peer Reviewed Orthopedic Research Program Pakistan Dec. 2008, Jul. 2010 On Road Drivers Training Initiated at WRAMC
2009	<ul style="list-style-type: none"> Center of Excellence Work Group established Power Knee Hand transplant policy developed Initial VA patient fit with DEKA Arm Conference for VA Amputation System of Care EACE interim director named DoD/VA Amputation System of Care

- Regulatory Activities
- Education Activities
- Facilities
- Research Activities
- International Mission Activities



2010	<ul style="list-style-type: none"> ● Textbook of Military Medicine Care of the Combat Amputee DoD/VA collaboration ● Army Hand Transplant Advisory Group Established ● JRRD Single Topic issue Traumatic Limb Loss ● iWalk Power Ankle ● England
2011	<ul style="list-style-type: none"> ● Dismounted Complex Blast Injury Task Force stood up by US Army OISG ● Thailand ● Estonia ● First EACE Job Position Announced ● Republic of Georgia ● VA Amputation System of Care FOC

- Regulatory Activities
- Education Activities
- Facilities
- Research Activities
- International Mission Activities

Adapted from Shero, J. 2014. ²⁰⁴

References

204. Shero J. Timeline of Important Events in Amputation Patient Care. 2014.



APPENDIX F. PATIENT FAMILY STORY

Jay Raffetto's Story Shared by John Raffetto

My older brother was a Naval Aviator from 1965 to 1995. I was in the Air Force from 68-72 as an Air Traffic Controller. Our older son was a Marine Rifleman from 98-02. Jay attended college for a year; worked construction for 3 years; worked in a restaurant in Chicago for a year before joining the Navy in 2006. After boot camp he entered basic corpsman training. He then decided to volunteer for Special Amphib Recon Corpsman training. He completed that arduous program and joined the fleet at Camp Pendleton in 2009. He deployed to Afghanistan in May, 2010.

On August 5, 2010 at 10AM, Jen received a frantic call at her office from Jay's wife Emily. Emily was calling from Camp Pendleton to let us know that Jay had stepped on an IED while on patrol with his Marines in the Helmand Province and lost both legs above the knee, his left arm above the elbow and the bottom 3 fingers on his right hand. He was in very bad shape but was expected to survive. His torso, face, and brain were apparently in good condition. Jen and I, along with Emily's parents flew from Philadelphia to San Diego at 3PM that afternoon. The next day we had a briefing at Emily and Jay's apartment by a joint Navy/Marine/family services team. It was very frank, sensitive, and helpful.

After a few days in California we all headed to Bethesda as Jay was expected to arrive there on Sunday. While in an induced coma, he was doing well and would be arriving sooner than expected. We were in constant contact with various Marine and Navy representatives. While the news was so hard to comprehend, it all became so relative and we were just so *thrilled* that Jay was alive.

On Sunday, August 8, 2010, just three days after being wounded on the battlefield, Jay and his life-support pod arrived at Bethesda Naval. He was nothing but tubes and machines but it was such a joyous moment. The next few days/weeks were a whirlwind of very small advances but the docs and nurses were so helpful. Dr. Donne was the lead doc and he would sit down with us and give all the details. He gave us his home phone and cell phone. Sounds small but at the time it was so monumental. We were desperate for any positive, personal contact.

Other highlights as the weeks unfolded: Marines from all over the country flew in to be with Jay; the Semper Fi Fund was really our life line both financially and emotionally; Fisher House was a true life saver. As Jay went through daily surgeries to clean out his wounds and rebuild the deep tissue damage to his remaining right arm, we would be counseled by the docs and Marines on what was happening, what wasn't and the daily prognosis. Our sense was that Jay and Emily were in VERY good hands. It was extremely significant that Emily was able to spend every moment (24/7) at Jay's side.

Over the next few months the on-going progress was slow but steady, Jay and Emily's mental states were beyond positive. Jay's right arm was rebuilt with tissue from his back. The staff at the Walter Reed MATC (the merger had not yet occurred) was so upbeat and comforting. We



commuted from Philadelphia and loved to see the progress as Jay continued to work so hard on getting upright.

On August 16th I had my previously scheduled annual physical with my family physician (also Jay's). I explained Jay's injuries and situation. A week later I had dinner with some local businessmen and J.D. DiBuonaventuro, the head of the Chester County Hero Fund. The Fund had been founded in 2000 to help support local EMT, firefighters and police injured or killed in the line of duty. With the news of Jay's injuries the Fund decided to include Jay in the local effort. Over the next 3 ½ years J.D., the local community and the Raffetto family embarked on a support mission that has, among other things, provided a remodeled home and modest trust fund for Jay and Emily. This included Beef and Beers, local high school fundraisers, wine tastings at local restaurants and other events too numerous to mention. J.D. and I became inseparable in our 3-year focused mission to help Jay and Emily for the long haul.

So many baby steps as the months and years continued:

Early weeks – lots of supportive dinners in Bethesda and home with relatives and friends

August 13 – moved out of ICU

August 14 – Jay interviewed by psychologists about what happened; wanted to see both Jen and me alone to see how we were doing; “who's paying for all of this?”

August 15 - sitting up in bed

August 16 – Jay's 28th birthday

August 17 - sliding off the bed to a wheelchair – HUGE – getting his balance back; John back to work

August 18 – rod implanted in his right arm; went well.

August 24 – General Amos presented Jay with his Purple Heart; very moving for all of us.

August 25 – Jay and Em are ready to move to Walter Reed BUT Dr. Donne wants to wait to ensure they have a room where Emily can continue to stay with Jay.....THIS IS HUGE FOR ALL OF US!

August 26 – Jay got in and out of his wheelchair by himself

August 29 – can we bring Swedish Fish on next visit? Starting to see old Jay.

August 31 – Jay has a fever of 103 – not to worry!! What a roller coaster.

September 4 – skin graft on right arm went well. Lots of Marine visitors. It was made clear Jay could stay in Special Ops if he wanted....this kind of support was a very big deal.

September 9 – moved to Walter Reed (the old one) – kids liked the room

September 12 – sat outside in a 5th floor garden – a first. Jay explained the blast in great detail; saw his legs vaporize; recalls them placing his dismembered left hand on the stretcher.

September 14th – surgery to repair left ear drum

September 21 – moved to the Malogne House – room of their own

September 24 – went for a ride in Jay's car

October 1 – dinner out in Bethesda

December 13 – flew to Camp Pendleton to see unit upon their return from Afghanistan – he wanted them to see he was OK.

March 2011 – Emily starts back to college.



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I am convinced that one of the biggest plusses to Jay's recovery has been his love of what he was doing when he got hurt....taking care of his Marines.

August 2011 - Jay off all meds

September 2011 – renewal of their wedding vows before 175 guests; Jay and Em danced, with the help of his prosthesis.

And so it goes – one hurdle after another. I have a lengthy log that chronicles them all.

Fast forward to now. Jay and Emily live in a remodeled home in the DC suburbs donated by JP Morgan/Chase; Emily has graduated from U of MD and has plans for graduate school. Jay has his dream job at one of the intelligence communities.

Jay's femurs are very short and as such his "big legs" have not worked out but he spends a lot of "home" time on his short legs (no knees) and his "public" time in his wheelchair. He has a Ford F-150 with hand controls, which he drives to work and home.

So, after 51 months Jay and Emily live an incredibly normal, productive, and successful life, full of hard work, good friends and good times.

It's almost impossible to believe how far we have all come together. I attribute the success of this amazing young couple to all of the incredible medical support up front, the love, and support of so many friends and relatives, the Marines, their good jobs, and most importantly their love of each other and their unwavering positive attitude and very hard work.

John



APPENDIX G. DoD-VA COLLABORATIONS AS OF JULY 14, 2014, SUBMITTED BY EXTREMITY TRAUMA AND AMPUTATION CENTER OF EXCELLENCE

DoD-VA Virtual Rehabilitation Grand Rounds. Collaboration with DoD and VHA to create this valuable training initiative led to recurring bi-monthly virtual clinical education sessions. These virtual seminars provide state-of-the-science clinical training and award continuing medical education credits for providers across DoD and VA without travel costs and through a convenient delivery method.

- To date three presentations have been delivered to growing DoD-VA audiences. Attendance has risen steadily from 60 participants in the initial presentation to over 120 at the third presentation.
- Topics to date: Testing High Level Activities in Service Members and Veterans with Lower Limb Loss; Intrepid Dynamic Exoskeletal Orthosis and the Return to Run Clinical Pathway; and Translational Research for Prosthetic Feet: Implications on Function and Clinical Prescription.
- Accrediting Council for Continuing Medical Education and the American Occupational Therapy Association are awarding CMEs for participation.

Deployment of Integrated Communications Across the Federal Amputation System of Care:

- **Federal Amputation Interest Group (FAIG).** The FAIG is a listserv of over 500 VA and DoD interested professionals serving veterans and/or Service members with limb loss either directly or via consultation. It is the first interagency platform to share clinical knowledge, research and discussion on functional limb loss care.
- **EACE SharePoint Site.** The site is a DoD and VA web-based collaborative platform which offers a system to enhance process integration and workflow automation capabilities.
- **MOVI Cameras.** The EACE deployed approximately 40 high-definition web-cameras within the EACE Executive Office as well as the Advanced Rehabilitation Centers (MATC – Bethesda, MD; CFI – San Antonio, TX; C5 – San Diego, CA). This equipment provides an efficient and cost effective method to support professional exchange of information over significant distances by electronic means.
- **Federal Amputation System of Care (FASoC) TELCON.** This EACE-sponsored monthly teleconference is a forum for the Clinical Directors of the DoD Advanced Rehabilitation Centers and the VA Regional Amputation Centers to exchange information and explore common initiatives.



Research Collaborations:

- Collaboration has begun between the EACE, and the VA to leverage longitudinal assessment protocols from the Naval Health Research Center (NHRC)-led Wounded Warrior Recovery Project (WWRP) Quality of Life Survey and Millennium Cohort Study. The EACE's partnership with the NHRC is designed to support EACE researchers with a registry, improve data quality of the amputee patient population, and track their health outcomes over a lifetime of care.
- EACE, DoD, and VA researchers published a series of papers describing clinical efficacy of the BiOM®, a prosthetic ankle device designed to provide artificial muscle power that enables amputees to walk with reduced fatigue and pain, improved stability and balance, and enhanced overall quality of life. Further, EACE, DoD, and VA researchers successfully competed for and received \$1.4M of research funding to collaboratively pursue this line of research.
- The “Comprehensive High-level Activity Mobility Predictor (CHAMP)” was developed by a VA researcher as a performance-based assessment instrument to quantify high-level mobility in Service Members with traumatic lower limb loss. Six papers authored collaboratively by DoD, EACE, and VA researchers were accepted for publication in FY2013 that demonstrate the validity of this tool to discriminate between different levels of lower limb loss and to establish reference ranges for Service Members with and without limb loss. This valuable tool is now being used at the ARCs to aid clinicians and patients in tracking the progression of rehabilitation, and in setting realistic goals to reach full functional potential following amputation.
- EACE personnel participated in development of the second edition of the VA-DoD Collaboration Guidebook for Healthcare Research, published in November 2013 at: <https://cdmrp.org/files/forms/generic/va-dod-guidebookresearch-collaboration.pdf>. This updated guidebook will facilitate continued development of stronger collaborative human subject research relationships between VA and DoD. Such collaboration results in improved research initiatives, as well as pooled financial and human resources, which increases our research efficiency and credibility.
- DoD and VA personnel from the EACE participated as “Chair” and members of the Scientific Steering Committee for Neuromusculoskeletal Rehabilitation, Clinical and Rehabilitative Medicine Research Program, U.S. Army Medical Research and Materiel Command (MRMC), to identify and summarize clinically meaningful research gap areas that facilitated DoD and VA research funding decisions. EACE invited representatives from the Amputee Coalition of America, Telemedicine and Advanced Technology Research Center (TATRC), two VA ASoC sites, three DoD medical treatment facilities, the Army Medical Department Center & School, and MRMC to work collaboratively to achieve this goal. The team also modified EACE key research initiatives to align with defined gap areas.
- EACE and VA personnel collaborated with the DoD funded “Bridging



Advanced Developments for Exceptional Rehabilitation” (BADER) research consortium team to successfully develop and receive \$1.4M in funding for a study that builds on FY 2012 NATO recommendations to further develop a functional outcomes assessment toolkit that can be used to standardize outcomes measurement across the DoD and VA. This study is currently in the literature review phase to be followed by data collection phase across five DoD and VA sites.

- **DEKA Arm Take-Home Study.** Two VA and one DoD site are participating in a study to examine the feasibility, acceptance, and benefits of home use of an advanced upper limb prosthetic device, as well as the logistical support requirements utilized during three months of home usage. The DEKA Arm recently received Food and Drug Administration (FDA) approval and has the potential to offer a significant number of veteran and Service member amputees a device that more closely mimics natural human function than any previous upper extremity prosthetic.

Clinical Practice Guideline (CPG) Update. The DoD-VA Upper Limb Amputation Rehabilitation CPG is on-track for publication this summer. Subject matter experts from both Departments have been working collaboratively to accomplish this critical task. Having this CPG will culminate in reduced practice variance, an enhanced standard of care, accelerated research translation into clinical practice, and ultimately lead to improved health, quality of life, and satisfaction for this population of patients.

Artificial Limb Procurement through the Denver Acquisition and Logistics Center (DALC): The VA is engaged in an Integrated Product Team (IPT) to understand the current and future orthotic and prosthetic limb technologies and to use this specialized knowledge to develop contracts that will provide best value for the internal purchase of orthotic and prosthetic limb components and supplies to the VA. The EACE is a member of the IPT and proposes a Proof of Concept trialing the DALC at Naval Medical Center San Diego to determine if use of the DALC for orthotic and prosthetic components will realize the benefits of volume purchasing and centralized distribution to achieve cost efficiencies and increased clinical staff and patient satisfaction for DoD.

Joint Agency Clinical Video Telehealth (CVT): Planning is underway to offer CVT services to veterans and Service members with a goal is to facilitate continuity of care while also providing the expertise that may not be available within the agency that is providing care. A pilot is being explored between VA New York Harbor Healthcare System and Walter Reed National Military Medical Center.

Federal Advanced Amputation Skills Training Symposium (FAAST): The first DoD-VA advanced amputation skills training was held 8 -- 10 July 2014. The purpose of this symposium was to provide VA and DoD healthcare professionals working in limb loss care an arsenal of the latest tools and techniques that can be used to assist Service members and veterans with limb loss in reaching their highest level of function, with a specialized focus on the complex needs of the multiple limb amputee. This included providing a comprehensive update on rehabilitation principles, state-of-the-art prosthetic technologies, and research in the area of limb loss care. DoD professionals presented information on issues facing the new traumatic amputees from



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OEF/OIF/OND that are transitioning care to VA. VA experts shared their knowledge and skills in providing care throughout the patient lifespan to this unique population. This training symposium is crucial for our VA and DoD clinicians to share their knowledge as well as build their professional network to facilitate the delivery of the most comprehensive and highest quality care available to our veterans and Service Members living with limb loss.

Congressional Update. The EACE maintains responsive communications with Congress.

- Our required FY13 EACE Annual Report was written and staffed jointly at DoD and VA Central Office (VACO) to obtain dual signatures prior to submission to Congress. The National Defense Authorization Act (NDAA) for Fiscal Year 2014 (House Report 113-102) required the Secretary of Defense to report on the DoD's effort to advance lower extremity prosthetics and orthotics, and the process by which such advancements are made available to members of the Armed Forces in a timely manner. This report was primarily written by DoD, but jointly staffed with the VA. A similar report was required by NDAA 2014 (Section 724) on Provisions of Advanced Prosthetics and Orthotics to Members of the Armed Forces and veterans. This report was authored by the VA, jointly staffed with DoD, and is currently enroute to Congress.
- The EACE and accompanying VA subject matter experts presented to the House Veterans Affairs Committee at their request in March 2014. The focus was an overview of the EACE activities with a focus on VA contributions/collaborations.
- In July 2014 the EACE presented at a Congressional panel discussion titled: "Back in Action: Mobilizing the American Wounded Warrior with Modern Prosthetics". This panel discussion was provided to interested Congressional staffers on the history and importance of DOD funding for Research and Development as related to prosthetics for Wounded Warriors. The panel demonstrated to the audience the advanced prosthetics collaboration between the DoD, VA, and the Defense Advanced Research Projects Agency (DARPA).

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APPENDIX H. STANDARDS AND CHARACTERISTICS OF THE BEST CARE

Operational Characteristics of a World-Class Health Care Facility as Defined by the Defense Health Board^{105(pB-1-B-8)}

To be considered world class, a medical facility must meet at least the 18 conditions in the 6 domains specified below.

I. Basic Infrastructure

The facility:

1. Has attained and maintains all accreditations and certifications that satisfy licensure and other statutory and regulatory requirements relating to the provision of the services offered at the facility.^j
2. Provides comprehensive and definitive acute healthcare services in an integrated and coordinated manner that meets patient needs from birth (including the pre-term neonate) through the end of life, as demonstrated by, but not limited to:
 - a. providing services in all the specialty areas recognized by the American Board of Medical Specialties (ABMS), in so far as these specialties are reasonable and appropriate for the needs of the patient population and community served;
 - b. offering services in a preponderance of the subspecialty areas recognized by the ABMS; and
 - c. having clearly specified policies and procedures for referral and transfer of patients for highly specialized services that are generally centralized to a few locations (e.g., definitive burn care, organ transplants, spinal cord injury care, and rehabilitation), if such services are not provided at the facility.
3. Has a high degree of facility readiness to provide high quality care as demonstrated by at least the following characteristics:
 - a. application of contemporary evidence-based knowledge and principles of design and construction and the utilization of state-of-the-art technology to, among other things:
 - i. create a healing environment and continuous healing relationships;
 - ii. optimize the patient room environment and functionality for:
 1. providing patient/family-centered care;
 2. supporting the patient's and family's direct involvement in care delivery;
 3. minimizing the need for patient movement; and
 4. allowing direct visual monitoring by caregivers.
 - iii. facilitate effective communication between and among caregivers, patients and families;
 - iv. support information management, as reflected by attaining at least stage 6 of the Healthcare Information and Management Systems Society (HIMSS) Electronic Medical Record Adoption Model;

^j For example, the Joint Commission, American Osteopathic Association (AOA) or Det Norske Veritas (DNV) accreditation; Accreditation Council for Graduate Medical Education (ACGME) postgraduate physician residency program accreditation; certifications by the American Association of Blood Banks, American College of Radiology, American College of Surgeons, College of American Pathologists, Nuclear Regulatory Commission, and the Food and Drug Administration's Division of Mammography Quality and Radiation Programs.



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- v. minimize the occurrence of healthcare-related infections;
 - vi. facilitate real time location tracking of patients and staff;
 - vii. reduce patient and staff stress;
 - viii. encourage retention of staff;
 - ix. utilize unified communications;
 - x. support facility navigation and way-finding; and
 - xi. achieve functional integration of component parts and processes into a coordinated system;
 - b. assurance of equal access for all patients, families, and staff to all clinical and routine nonclinical areas and activities throughout the interior and exterior areas of the facility by providing a physical barrier-free environment that exceeds minimum American with Disabilities Act (ADA) requirements;
 - c. development and regular testing of plans for continuity of operations during times of emergency or catastrophe due to epidemic, weather, or other acts of nature, technological failure, or terrorism, inter alia;
 - d. incorporation of significant flexibility and adaptability in the facility design and construction to accommodate changing practices and processes of care resulting from new knowledge, as well as optimization of surge capacity to accommodate the need to treat and manage unexpected large numbers of additional patients as might occur with an epidemic or disaster.
4. Assures that caregivers and other staff are prepared to perform competently and otherwise appropriately by, among other things:
- a. promulgating policies for and standards of performance, conduct, and ethical behavior for all personnel, including job-specific and specialty-specific standards, as appropriate;
 - b. monitoring the performance of all employee's [sic] on a regular basis (at least annually) by direct observation of performance, formal testing, supervisor and peer review, patient feedback, and/or other methods, as appropriate to the position;
 - c. providing feedback of monitoring results to the employee and, if relevant, concerned parties, together with counseling, mentoring, and personal improvement or remediation programs, as needed;
 - d. promptly investigating all complaints or concerns voiced about the competence or safety of a caregiver's performance; and
 - e. carrying out whatever other actions are necessary to ensure that all caregivers and other staff are properly trained, equipped, fit, and otherwise fully prepared to perform their assigned jobs.

II. Leadership and Culture

- 1. Provides executive leadership that is:
 - a. visionary and mission-focused;
 - b. experienced with demonstrated competence in the critical competencies identified by the National Center for Healthcare Leadership and the American College of Healthcare Executives (1);
 - c. stable over time; and
 - d. empowered with organizational and fiscal authority.
- 2. Organizes its governance structure and processes to, among other considerations:



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- a. ensure that the governing body is composed of appropriately knowledgeable and dedicated individuals who reflect and represent the interests of the organization and its stakeholders and who recognize the competencies required for excellent leaders;
 - b. facilitate effective communication with its medical staff and employee representatives;
 - c. assure that patient and patient family's views and perspectives about facility operations are known to facility management and the governing board; and
 - d. ensure that the governing board is actively involved in overseeing the operation of the institution, and especially in overseeing the quality and safety of care provided.
3. Manifests an organizational culture that:
- a. continually strives for excellence, as demonstrated by, among other things:
 - i. the organization's mission, vision, core values, bylaws, and strategic objectives;
 - ii. the attainment of, or being in the process of attaining, the highest level of certification or designation for specialty services having generally recognized tiered levels of service;^k
 - iii. having been awarded "magnet status" by the American Nurses Credentialing Center (ANCC);B-5
 - iv. receipt of awards for excellence in organizational performance;^l
 - v. establishment of multidisciplinary Centers of Excellence; and
 - vi. the reputation and professional accomplishments of its staff;
 - b. seeks to be a high reliability organization by demonstrating, among other characteristics, proactive and relentless vigilance in
 - i. avoiding preventable patient harm, and
 - ii. improving process effectiveness and efficiency;
 - c. actively encourages and rewards innovation;
 - d. promotes and supports teamwork, collaboration and partnerships, as demonstrated by, among other manifestations:
 - i. formally established collaborative relationships with other institutions and professional organizations;
 - ii. routine utilization of one or more formal teamwork training methodologies for staff; and
 - iii. recognition and awards for exceptional team performance and success;
 - e. creates a work environment that promotes employee satisfaction and well being by, among other things;
 - i. fostering an environment of civility and respect for patients and employees;
 - ii. reporting and addressing lateral violence;
 - iii. supporting professional development; and
 - iv. offering services such as child and elder care programs, telecommuting, flexible work schedules, and employee wellness and fitness programs;
 - f. is pro-active and non-punitive in identifying medical errors and recognizes medical errors and preventable adverse events as opportunities for process improvement, as demonstrated by, among other things:
 - i. utilization of a formal adverse event and near-miss reporting system;

^k For example, level 1 trauma center or comprehensive cancer center.

^l For example, Malcolm Baldrige National Quality Award or state or regional quality awards.



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- ii. routine application of clearly defined policies and procedures for root cause analysis and failure mode and effects analysis; and
 - iii. establishment of formal processes of learning from the occurrence of adverse events;
 - g. recognizes the importance of culture, education, spiritual beliefs, life experience, and health literacy on a person's response to injury or illness, their understanding and acceptance of diagnostic interventions and treatment, and in the healing process;
 - h. nurtures efforts to advance the frontiers of knowledge and to pioneer improved processes of care; and
 - i. understands that its responsibility does not stop at the hospital walls and recognizes the need to support, among other activities:
 - i. patient-focused care coordination, and
 - ii. systematic examination of antecedents of hospitalization to reduce the need for such care.
- III. Processes of Care
1. Organizes its services so that they are integrated and seamless between and among services in the facility and with home and community-based services.
 2. Consistently applies contemporary evidence-based knowledge and principles and utilizes state-of-the-art technology in executing the following processes, among others:
 - a. diagnosis;
 - b. treatment;
 - c. documentation and records keeping;
 - d. medication management;
 - e. communication and care coordination;
 - f. knowledge management;
 - g. materiel management; and
 - h. business processes.
 3. Routinely operationalizes evidence-based practices and processes in the delivery of care, including, but not limited to, those that:
 - a. implement the most recent set of "Safe Practices" endorsed by the National Quality Forum (2);
 - b. minimize the likelihood of the occurrence of the "never events" identified by the National Quality Forum (3);
 - c. implement the 6 aims and 10 "design rules" for healthcare in the 21st century espoused by the Institute of Medicine (4);
 - d. comply with the most recent National Patient Safety Goals and related specific expectations set by The Joint Commission (5);
 - e. are connected with known life-saving interventions such as evidence-based care for myocardial infarction, medication reconciliation, and the ventilator bundle;
 - f. evaluate the quality of care provided to its sickest patients (i.e., those who die) by routinely utilizing the autopsy for quality assurance and education; and
 - g. utilize formal quality and process improvement methodologies as an integral element of all care processes.
 4. Demonstrates transparency of processes by, among other manifestations:
 - a. routinely involving patients, patient families, and employees in reviewing and determining the processes of care;



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- b. ensuring that patients are provided with complete information about their care that is appropriate to their level of healthcare literacy so that they can make informed decisions and fully participate in all decisions about their care;
- c. responding openly, promptly, and honestly when patients are injured by unanticipated adverse events or anticipated complications by:
 - i. informing the patient and/or the patient's designated representative, as appropriate, of what has happened and what will be done to remediate any injury and mitigate further injury;
 - ii. investigating the cause(s) of the event and reporting the findings to the patient and/or the patient's designated representative, as appropriate;
 - iii. providing emotional support for the patient as well as the caregivers involved in the adverse event; and
 - iv. apologizing to the patient and his/her family and/or the patient's designated representative, as appropriate, when the institution or caregivers are responsible for the event; and
 - v. compensating the patient for costs associated with injury.
- d. making publicly available performance data and de-identified results of root cause analyses.

IV. Performance

- 1. Complies with all relevant federal government performance reporting requirements
- 2. Demonstrates superior performance (e.g., greater than the 90th percentile) against standardized industry metrics, including but not limited to those for:
 - a. clinical care;^m
 - b. patient satisfaction;ⁿ
 - c. employee satisfaction;
 - d. employee sick leave, absenteeism and retention;
 - e. work-related injuries and illnesses; and
 - f. stewardship of resources as reflected by expense control, operating efficiency and adequacy of revenue or appropriation to support sustained high level performance, among other considerations.

V. Knowledge Management

- 1. Is regularly engaged in a full spectrum of scholarly activities, including, but not limited to:
 - a. providing [GME] and other health professional training;
 - b. conducting research, having its faculty and staff speak at scientific meetings and publish in peer-reviewed professional journals; and
 - c. utilizing a dedicated process to monitor, translate and apply research findings into clinical care, including a process for evaluating the results of new processes or pilot programs.
- 2. Has simulation laboratories for surgery, cardiac catheterization, endoscopy, and emergency care, at a minimum.

VI. Community and Social Responsibility

^mNQF endorsed performance measures for hospital and ambulatory care.

ⁿNQF endorsed performance measures for patient satisfaction (H-CAPHS), American Consumer Satisfaction Index [*sic*] and loyalty.



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1. Demonstrates a population health focus by routinely being involved in activities aimed at improving the community and constituency that it serves, as demonstrated by, but not limited to:
 - a. hosting or supporting health maintenance and disease early detection programs; and
 - b. participating in local and regional disaster readiness programs; and
 - c. working with other organizations on community improvement projects.
2. Demonstrates environmental responsibility and sustainability in the facility design, construction and operation by, but not limited to:
 - a. having achieved Leadership in Energy and Environmental Design (LEED) certification;
 - b. embracing the recommendations contained in the latest edition of the *Green Guide for Healthcare*; and
 - c. disposing of potentially reusable medical devices with a Food and Drug Administration (FDA) cleared medical device reprocessor.
3. Demonstrates prudent use of resources by continually striving to reduce waste and inefficiencies.^{105(pB-1-B-8)}

Joint Commission Disease-Specific Care Certification

Certification Requirements

Certified programs must demonstrate a systematic approach to care delivery and a commitment to performance improvement through ongoing data collection and analysis. Requirements address three areas:

- Consensus-based national standards, which cover:
 - Program management
 - Clinical information management
 - Delivering or facilitating care
 - Supporting self-management
 - Measuring and improving performance
- Effective use of evidence-based clinical practice guidelines to manage and optimize care.
- An organized approach to performance measurement and improvement activities.

On-site review

The on-site review identifies areas of strength and areas for improvement in program quality. The reviews are conducted by Joint Commission disease-specific care field reviewers who are clinicians in current practice, with specific clinical expertise. During the on-site visit, the reviewer will assess: how clinical outcomes and other performance measures are used to identify opportunities to improve care; leadership's commitment to improvements; and how patients are educated with respect to self-management and guidelines that are pertinent to them. Surveyors will also validate that evidence-based guidelines are incorporated into daily clinical practices. The cornerstone of The Joint Commission's on-site certification process is the tracer methodology, which involves the review of current patients being treated as part of the program. The tracer methodology is a way to analyze a program's system of providing care, treatment and services using actual patients as the framework for assessing standards compliance. Disease-specific programs that successfully demonstrate compliance during the on-site review are awarded certification for a two-year period. At the end of the first year, the organization is



required to participate in a conference call to attest to its continued compliance with the standards and to review performance improvement activities.

Performance measurement

Certified programs are required to regularly submit data to The Joint Commission through Joint Commission Connect, a secure extranet site. Standardized performance measures are currently available for two certification programs – primary stroke centers and advanced certification in heart failure. All other certified programs may use existing relevant performance measures or self-specify measures based on their goals for improvement.^{108(p1-2)}

Commission on the Accreditation of Rehabilitation Facilities Amputation Specialty Program Description

A person-centered Amputation Specialty Program utilizes a continuum of care with a holistic interdisciplinary team approach. Interventions address the needs and desires of the person served and family/support systems and include, but are not limited to medical, rehabilitation, behavioral, psychosocial, vocational, avocational, and educational needs; prosthetic, orthotic, and pedorthic services; equipment; self-management of healthcare; preventive strategies; identification and use of peer support; and techniques to facilitate empowerment. The program supports and establishes connections to the local and national community that enhance the quality of the person's everyday life. The person served actively participates as a member of the interdisciplinary team to develop and understand the services provided and the impact on his or her functional abilities.

The Amputation Specialty Program focuses on strategies of collaboration to impact perioperative care, prevention, minimizing impairment, maximizing independent function, and maximizing the quality of life of the person served. Through the use of performance indicators, the program measures the effectiveness of services provided across the continuum offered.

An Amputation Specialty Program may be provided in a variety of settings, including hospitals, healthcare systems, outpatient clinics, community-based programs, and residential or long-term residential services.^{110(p5-6)}

Characteristics of a Continuously Learning Health Care System

Dimension	Characteristics
Science and Informatics	<p><i>Real-time access to knowledge</i>—A learning health care system continuously and reliably captures, curates, and delivers the best available evidence to guide, support, tailor, and improve clinical decision making and care safety and quality.</p> <p><i>Digital capture of the care experience</i>—A learning health care system captures the care experience on digital platforms for real-time generation and application of knowledge for care improvement.</p>
Patient-Clinician Partnerships	<p><i>Engaged, empowered patients</i>—A learning health care system is anchored on patient needs and perspectives and promotes the inclusion of patients, families, and other caregivers as vital members of the continuously learning care team.</p>
Incentives	<p><i>Incentives aligned for value</i>—A learning health care system has incentives actively aligned to encourage continuous improvement, identify and reduce waste, and reward high-value care.</p> <p><i>Full transparency</i>—A learning health care system systematically monitors the safety, quality, processes, prices, costs, and outcomes of care, and makes information available for care improvement and informed choices and decision making by clinicians, patients, and their families.</p>
Continuous Learning	<p><i>Leadership-instilled culture of learning</i>—A learning health care system is stewarded by leadership committed to a culture of teamwork, collaboration, and adaptability in support of continuous</p>



Culture	learning as a core aim. Supportive system competencies —A learning health care system constantly refines complex care operations and processes through ongoing team training and skill building, systems analysis and information development, and creation of the feedback loops for continuous learning and system improvement.
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Adapted from Smith M, Saunders R, Stuckhardt L, McGinnis MJ. *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*. Intitute of Medicine. Washington, D.C.: National Academies Press, 2013.¹⁰⁶

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APPENDIX I. SUGGESTED STAFFING

Specialty	FTEs for 10 Ward Inpatients	FTEs for 20 Outpatients (Excluding TBI Impairment)
Orthopaedics	1	1
Physiatry	1	1
Physician Assistant	2	1
Physical Therapy	2	2
Physical Therapy Assistant	2	2
Occupational Therapy	2	2
Certified OT Assistant	2	2
Recreation Therapy	1	1
Nursing (RN)	1	0
Nursing (LPN)	2	0
Social Work	1	1.5
Case Management	0.5	1
Administrative Assistant	0.5	0.5

FTE: full-time equivalent

RN: registered nurse

LPN: licensed practical nurse

TBI: traumatic brain injury

OT: occupational therapy

From Pasquina, et al., 2009, Table 1-1, p 11¹⁵

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APPENDIX J. ACRONYMS

Acronym	Term
ACT	Amputation Care Team
ADB	Amputee Database
AFRICOM	U.S. Military African Command
APOC	Amputation Point of Contact
ARC	Advanced Rehabilitation Center
ASoC	Amputee System of Care
BADER	Bridging Advanced Developments for Exceptional Rehabilitation
BAMC	Brooke Army Medical Center
C5	Comprehensive Combat and Complex Casualty Care
CAREN	Computer Assisted Rehabilitation Environment
CARF	Commission on the Accreditation of Rehabilitation Facilities
CASF	Contingency Aeromedical Staging Facility
CDC	Centers for Disease Control and Prevention
CDMRP	Congressionally Directed Medical Research Program
CENTCOM	U.S. Military Central Command
CFI	Center for the Intrepid
CHAMP	Comprehensive High-Level Activity Mobility Predictor
COAD	Continuation on Active Duty
COCOM	U.S. Military Combat Command
CoE	Center of Excellence
CONUS	Continental United States
CPT	Clinical Procedure Technology Codes
CT	Computed Tomography
DARPA	Defense Advanced Research Projects Agency
DEKA	DEKA Research and Development Corporation
DHB	Defense Health Board
DoD	Department of Defense
DoDTR	DoD Trauma Registry
EACE	DoD-VA Extremity Trauma and Amputation Center of Excellence
EACE-R	DoD-VA Extremity Trauma and Amputation Center of Excellence Registry
EMED	Expeditionary Medical Encounter Database
EUCOM	U.S. Military European Command
FAAST	Federal Advances Amputation Skills Training Symposium



FACET	Forecasting and Capacity Evaluation Tool
FHP	Force Health Protection
FTE	Full Time Equivalent
FY	Fiscal Year
ICD	International Classification of Disease Codes
IDEO	Intrepid Dynamic Exoskeletal Orthosis
IED	Improvised Explosive Device
IOM	Institute of Medicine
ISS	Injury Severity Score
JIF	Joint Incentive Funding
MATC	Military Advanced Training Center
MDRO	Multidrug-Resistant Organism
MHS	Military Health System
MOS	Military Occupation Specialty
NDAA	National Defense Authorization Act
NHRC	Naval Health Research Center
NMCSD	Naval Medical Center San Diego
OCO	Overseas Contingency Operation
OCONUS	Outside the Continental United States
OEF	Operation ENDURING FREEDOM
OIF	Operation IRAQI FREEDOM
OIG	Office of the Inspector General
OND	Operation NEW DAWN
ORCCA	Orthopaedic Research Clinical Consortium Award
PACOM	U.S. Military Pacific Command
PANS	Polytrauma Amputation Network Sites
PEB	Physical Evaluation Board
PMA	Program Management Aid
Project CARE	Comprehensive Aesthetic Restorative Effort Program
PRORP	Peer Reviewed Orthopaedic Research Program
PTSD	Posttraumatic Stress Disorder
RAC	Regional Amputation Center
RTR	Return-to-Run
SAMMC	San Antonio Army Military Medical Center
SOUTHCOM	U.S. Military Southern Command



TATRC	Telemedicine and Advanced Technology Research Center
TBI	Traumatic Brain Injury
TMR	Targeted Muscle Re-Innervation
USAISR	U.S. Army Institute for Surgical Research
USAMRMC	U.S. Army Medical Research and Materiel Command
USD(P&R)	Under Secretary of Defense for Personnel and Readiness
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
VISN	Veterans Integrated Service Network
WRAMC	Walter Reed Army Medical Center
WRNMMC	Walter Reed National Military Medical Center
WWI	World War I
WWII	World War II



APPENDIX K. SUPPORT STAFF

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